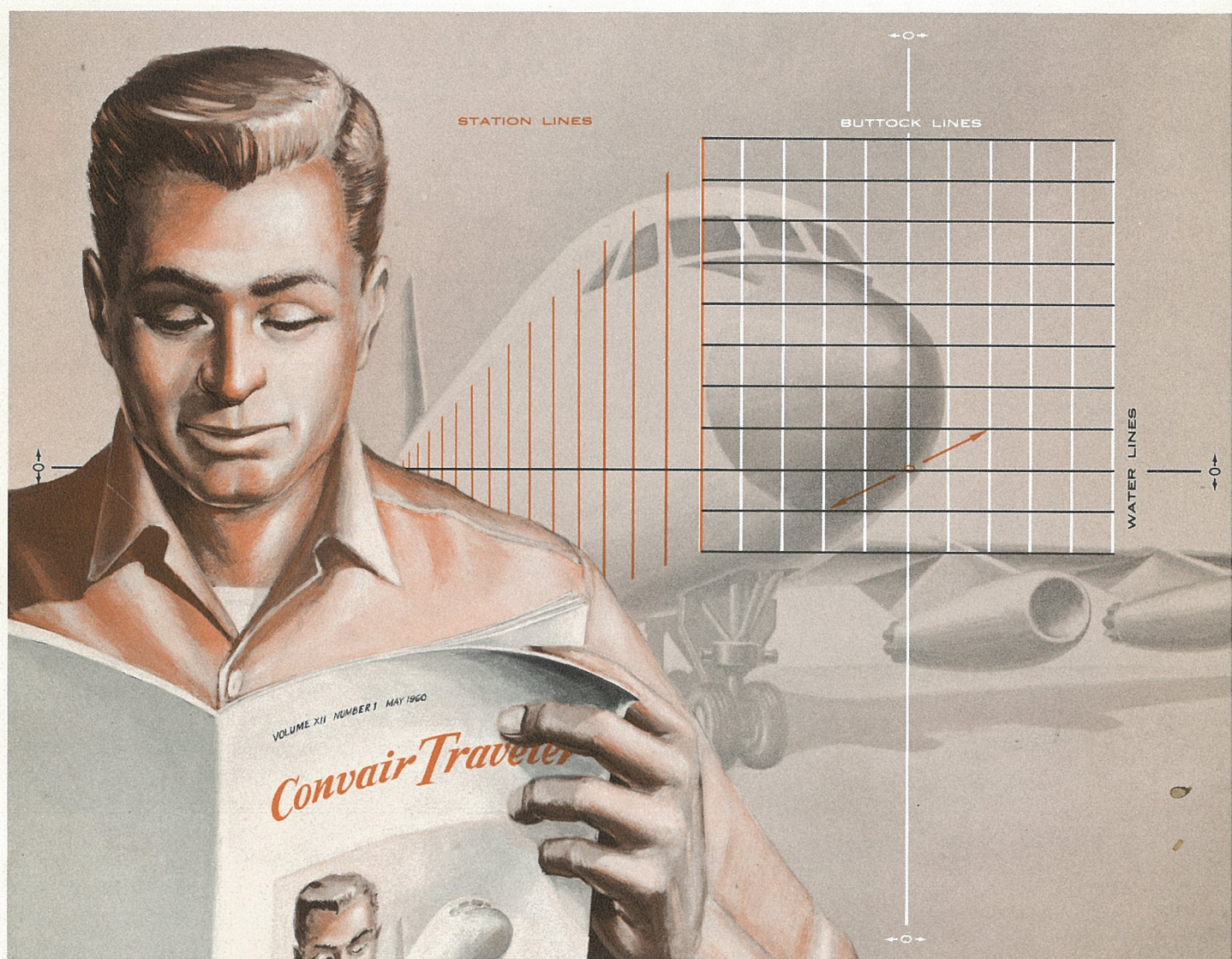


VOLUME XII

NUMBER 1

MAY 1960

Convair Traveler



In this Issue: Convair 600 Dimensions, Stations, and Geometry



Convair Traveler

VOLUME XII NUMBER 1 MAY 1960

MANAGER, CUSTOMER SERVICE — J. J. ALKAZIN
 CHIEF, TRANSPORT SERVICE — L. J. BORDELON
 CHIEF, SERVICE PARTS — J. DOIG
 CHIEF, SERVICE PUBLICATIONS — H. R. KENNEDY
 EDITOR — GERTRUDE S. HUNTER
 ART EDITOR — N. J. RUTHERFORD

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 MIL-L-7808C

Sam Urshan

PAGE 15

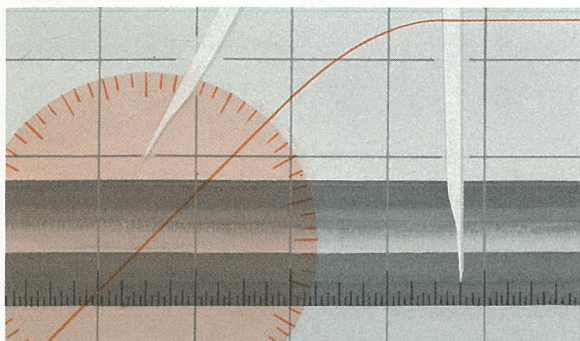
SAFETY WITH
 JET ENGINE FUELS

Sam Urshan

A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

OUR COVER

Some general orientation might help a man find his way through the whole library of blueprints that cover a Convair 600 jet airliner. Artist Norm Harrington thinks the May issue of the Traveler may be just what this man was looking for.



CONVAIR 600

Dimensions, Stations and Station Geometry, Access Doors and Service Panels

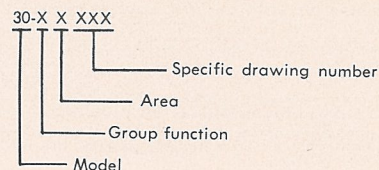
For the convenience of those who plan to service, maintain, and provide terminal facilities for the Convair 600 jet airliner, the pages following present dimensional data and airplane access information in a form available for quick reference.

Basic stations are given for wing bulkheads (pages 4-5), empennage ribs (6-7), fuselage belt-frames (pages 8-9), and engine pods (pages 12-13). Numbering of bulkheads, ribs, and access doors is according to systems used in Convair drawing references. Since wing and empennage have multiple station patterns, some of the geometry is given for orientation and for possible cross-reference use.

Overall dimensions of the "600" are on pages 8-9. On pages 10-11 are locations and actual heights from ground of the principal airplane service points, empty and fully-loaded conditions. This supersedes the information on pages 12-13 of the Traveler for September, 1959.

Equivalent data for the "880" are presented in the Traveler for April, 1959.

CONVAIR 600 DRAWING NUMBERING SYSTEM



- 30-0 GENERAL (proposals, specifications, general airplane)
- 30-1 WING AND EMPENNAGE
 - 11 Horizontal stabilizer
 - 12 Elevator
 - 13 Leading edges
 - 14 Vertical stabilizer & dorsal
 - 15 Rudder
 - 16 Wing
 - 17 Wing & trailing edge
 - 18 Aileron, tabs & flaps
 - 19 Wing tip and spoilers
- 30-2 POWER PLANT & AIR CONDITIONING
 - 21 Wing (power plant)
 - 22 Engine assembly
 - 23 Engine inst and removal
 - 24 Pylon
 - 25 Pod
 - 26 Fan duct
 - 27 Bleed air and ducting
 - 28 Low pressure ducting
 - 29 Major air cond components
- 30-3 ELECTRONICS
 - 31 Electronics compt - fwd
 - 33 Electronics compt - aft
 - 34 Wing and nacelles
 - 35 Vertical stabilizer
- 30-4 CONTROLS
 - 41 Fuselage - nose
 - 42 Fuselage - intermediate
 - 43 Fuselage - aft
 - 44 Wing
 - 45 Nacelles
 - 46 Vertical stabilizer and rudder
 - 47 Horizontal stabilizer and rudder
 - 48 Nose gear
 - 49 Main gear
- 30-5 ALIGHTING GEAR
 - 51 Main gear
 - 52 Nose gear
 - 55 Doors and mechanisms - gear
 - 57 Doors and mechanisms - fuselage
- 30-6 ELECTRICAL
 - 61 Fuselage - nose
 - 62 Fuselage - under cabin floor
 - 63 Fuselage - cabin
 - 64 Wing and pylon
 - 65 Engine pod
 - 66 Empennage and aft fuselage
- 30-7 FUSELAGE
 - 71 Nose section
 - 72 Fwd constant section
 - 73 Overwing section
 - 74 Aft constant section
 - 75 Tail section
- 30-8 HYDRAULICS, H-P PNEUMATICS
 - 81 Fuselage - nose
 - 82 Fuselage - intermediate
 - 83 Fuselage - aft
 - 84 Wing
 - 85 Nacelles
 - 86 Vertical stabilizer & rudder
 - 87 Horizontal stabilizer
 - 88 Nose gear
 - 89 Main gear
- 30-9 FURNISHINGS & GROUND SUPPORT
 - 91 Flight compartment
 - 92 Fwd cabin
 - 93 Passenger cabin
 - 94 Aft cabin
 - 95 Under-floor area
 - 99 Ground support equipment

WING STATION GEOMETRY

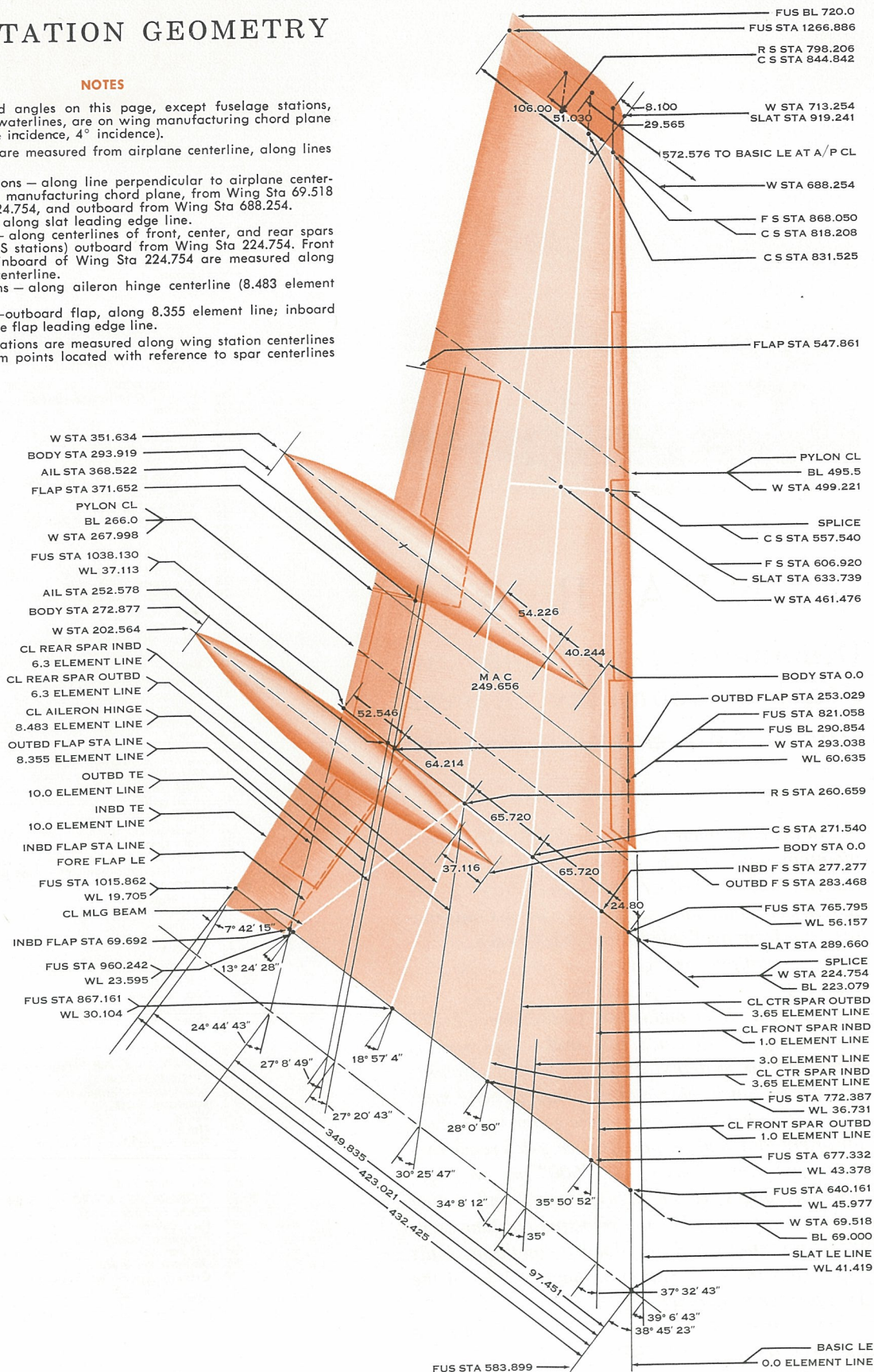
NOTES

All dimensions and angles on this page, except fuselage stations, buttock lines, and waterlines, are on wing manufacturing chord plane (7° dihedral before incidence, 4° incidence).

Structural stations are measured from airplane centerline, along lines as follows:

- 1 Wing (W) stations — along line perpendicular to airplane centerline, but along manufacturing chord plane, from Wing Sta 69.518 to Wing Sta 224.754, and outboard from Wing Sta 688.254.
- 2 Slat stations — along slat leading edge line.
- 3 Spar stations — along centerlines of front, center, and rear spars (FS, CS, and RS stations) outboard from Wing Sta 224.754. Front spar stations inboard of Wing Sta 224.754 are measured along inboard spar centerline.
- 4 Aileron stations — along aileron hinge centerline (8.483 element line).
- 5 Flap stations — outboard flap, along 8.355 element line; inboard flap, along fore flap leading edge line.

Anti-shock body stations are measured along wing station centerlines of the bodies, from points located with reference to spar centerlines as shown.



WING BULKHEAD STATIONS AND ACCESS PANELS

NOTES

Bulkhead numbers, and numbers on wing access panels, are those referenced in Convair drawings. Panels No. 1 through 18 are for wing tank access; panels No. 19 through 41 are for flap, aileron, and spoiler mechanisms access. Letters identify panels as follows:

A Compass Flux Valves (RH wing only) **B** Airscoop **C** Tube Disconnects **D** Slot Hooks **E** Bearings **F** Bleed Air and Electrical **G** Float Switch **H** Boost Pump **J** Transfer Pump **K** Inspection Doors **L** Landing Light **M** Refuel Panel **N** Bellows and Torque Tube Couplings

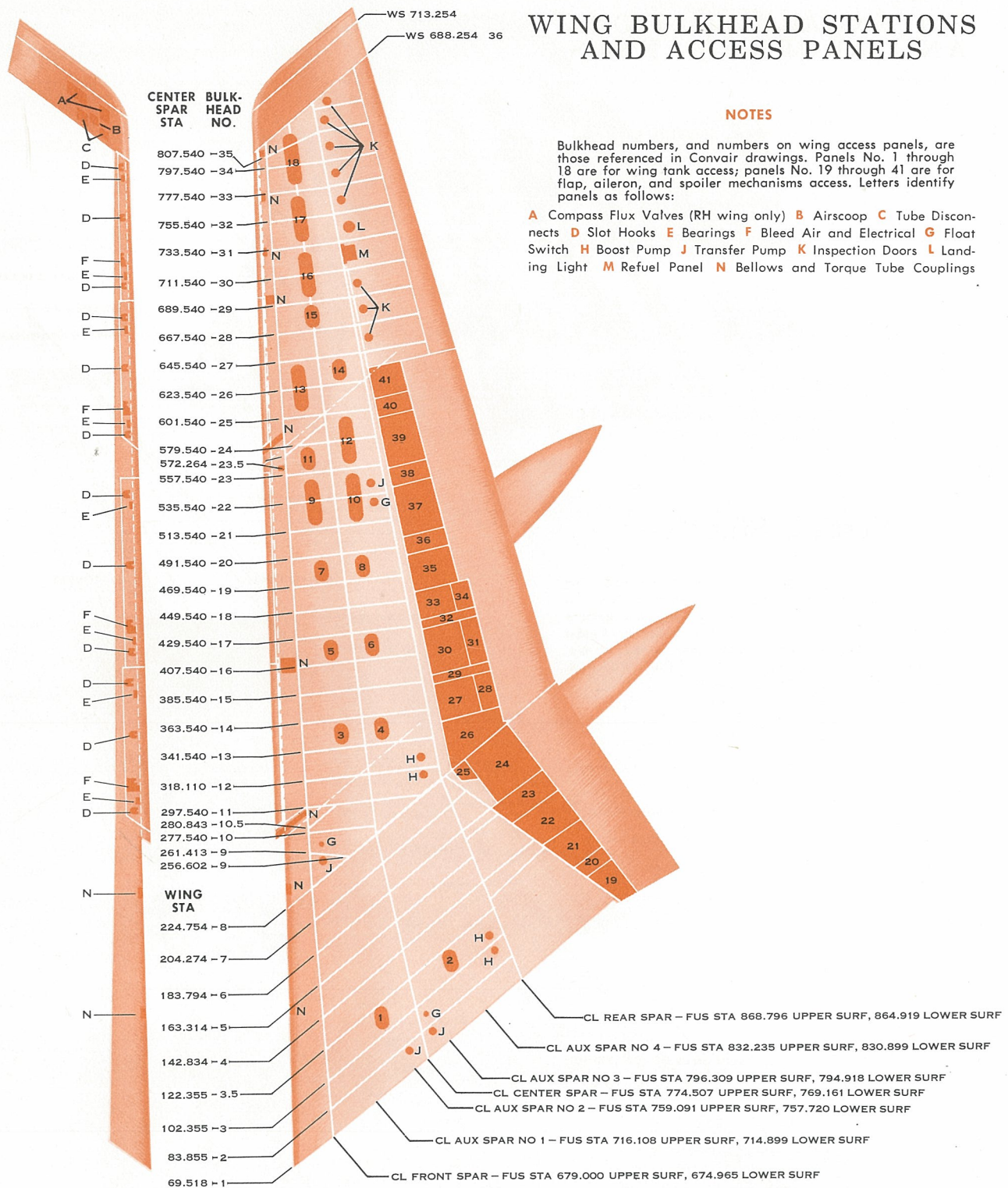
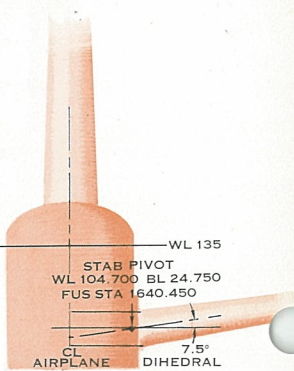


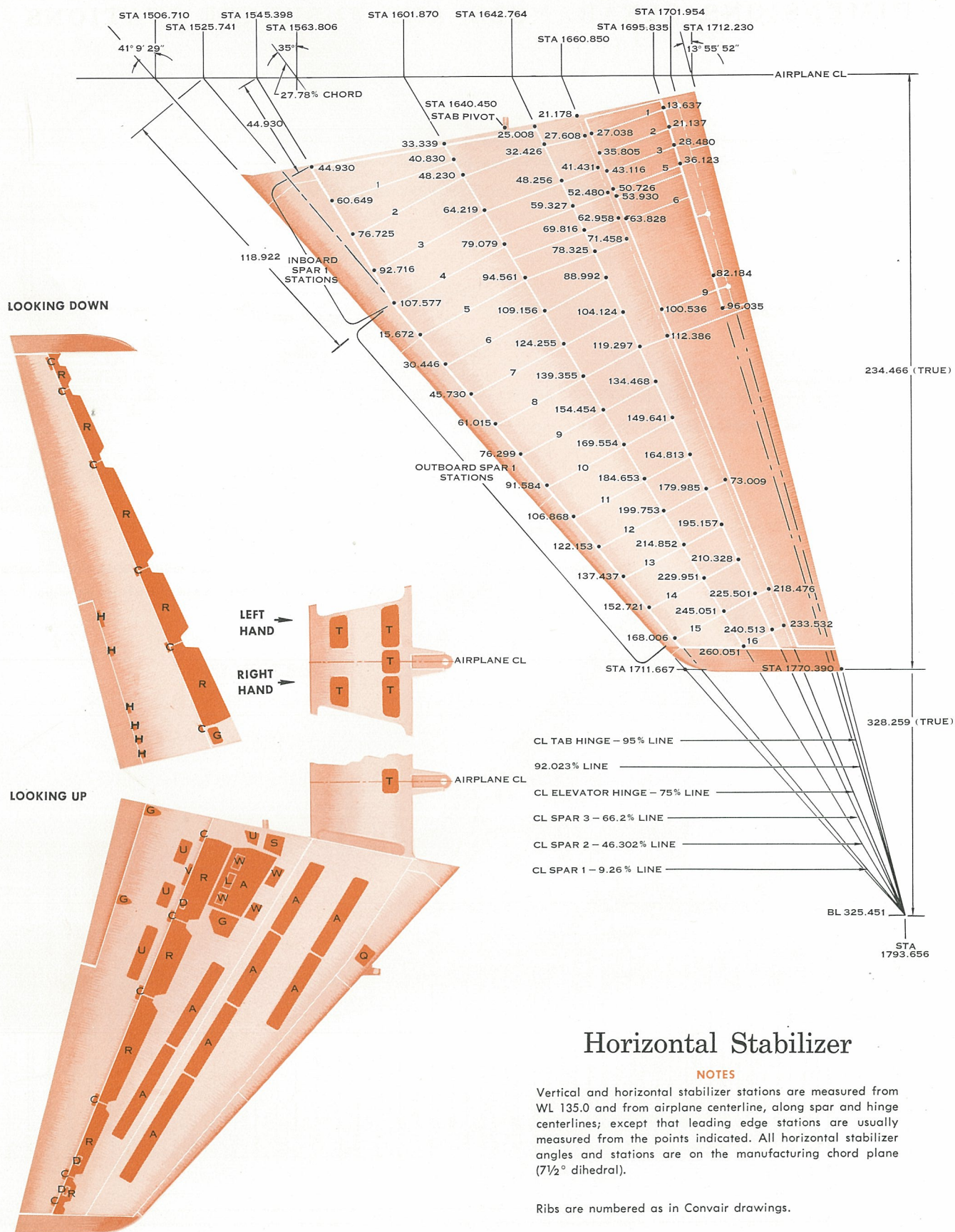
Diagram illustrating the layout of Pennage Stations and Access Panels. The diagram shows two main sections, each with a series of stations labeled A through O. The stations are arranged in a linear fashion, with access panels (indicated by small circles) located between them. The layout is shown in a perspective view, with the stations and panels arranged in a series of parallel lines.

RIGHT HAND

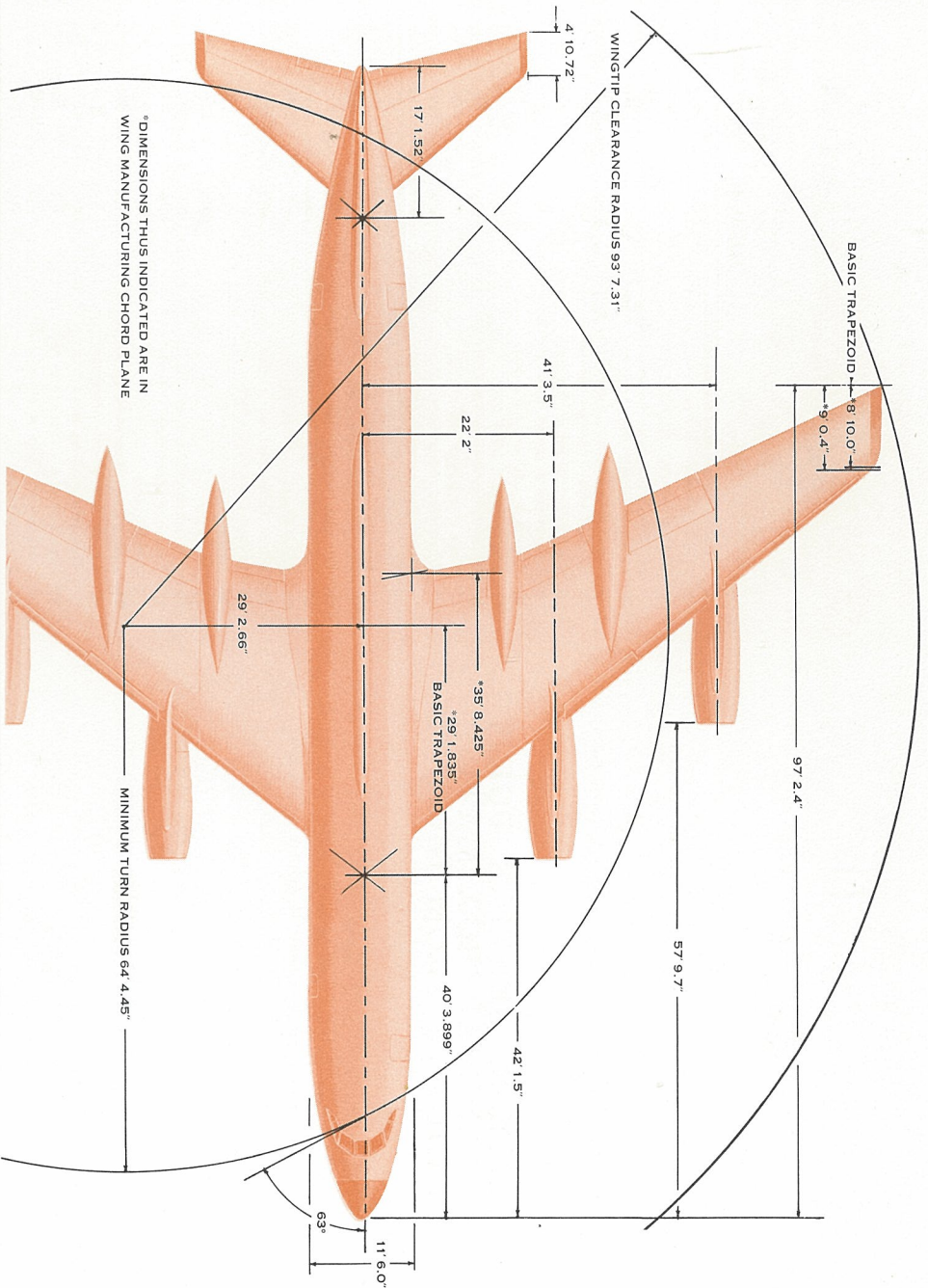
NOTES

- A Structural Access B Antenna Tuner C Hinge Bearing
D Flutter Damper E VHF Coupler F Tab Horns G Tab Rods
H Tab Hinge J Tab Flutter Damper K Hinge, Rib, Balance
Board Mechanism L Gust Damper M Restrictor N Rudder
Actuator P Balance Board Shrouds Q Ram Air Duct R Balance
Weight S Pivot Bearing T Torque Box U Controls
V Gust Damper Arm W Pressure Boards

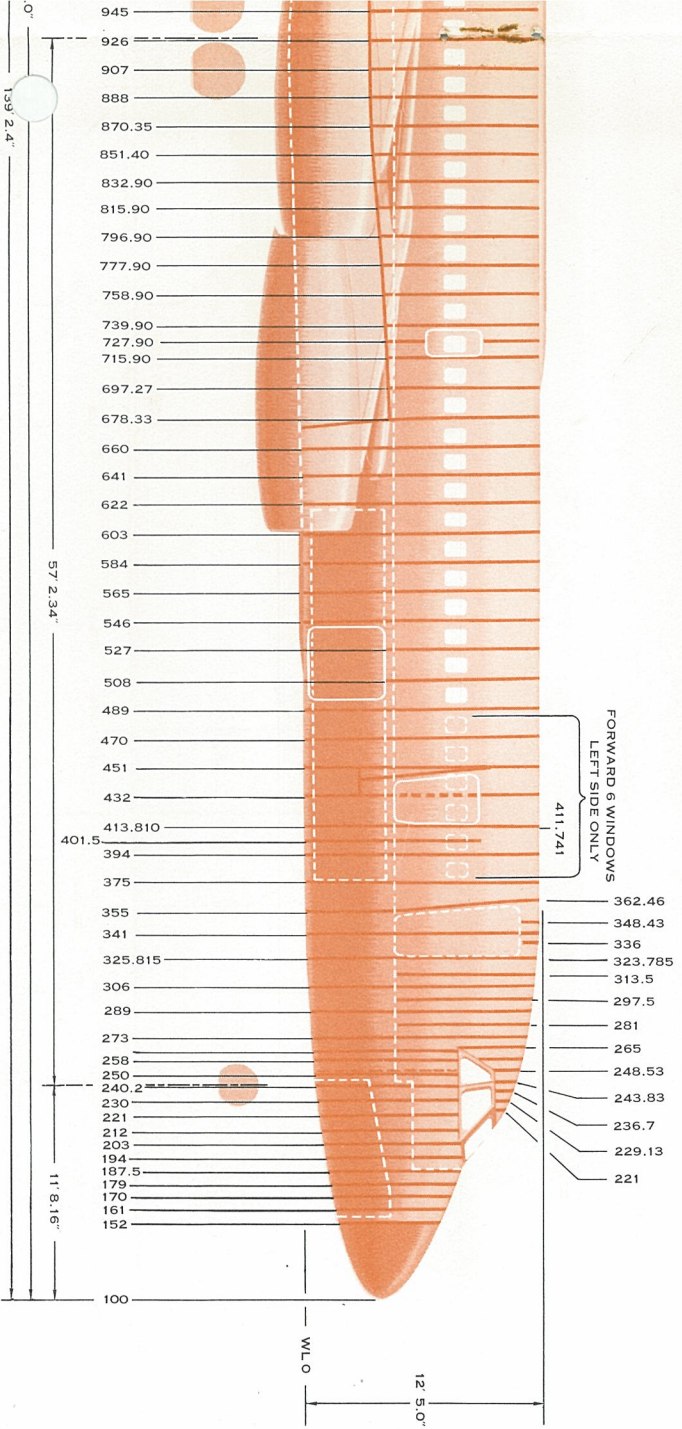








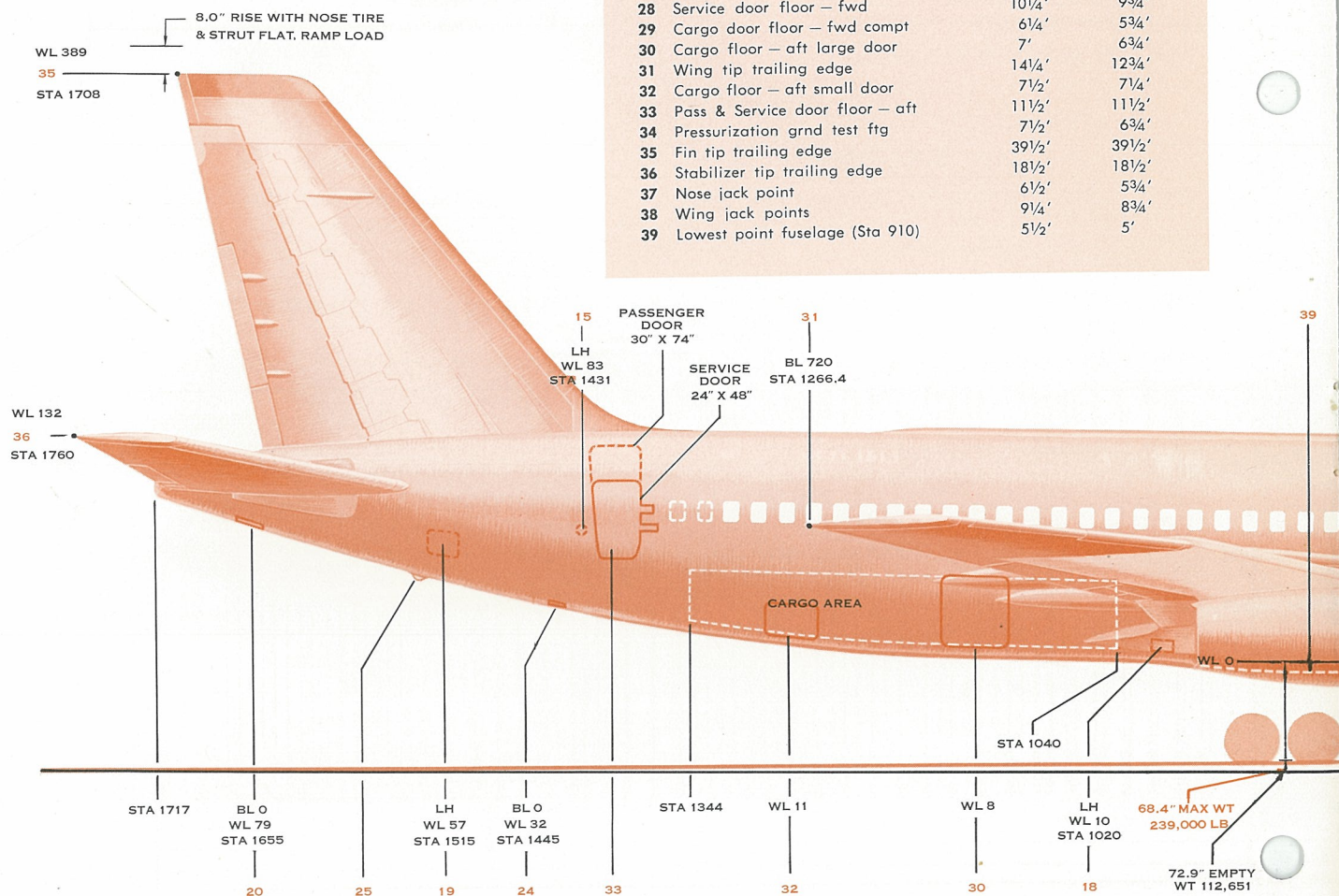
*DIMENSIONS THUS INDICATED ARE IN WING MANUFACTURING CHORD PLANE



ACCESS, SERVICE POINTS AND APPROXIMATE HEIGHTS FROM GROUND

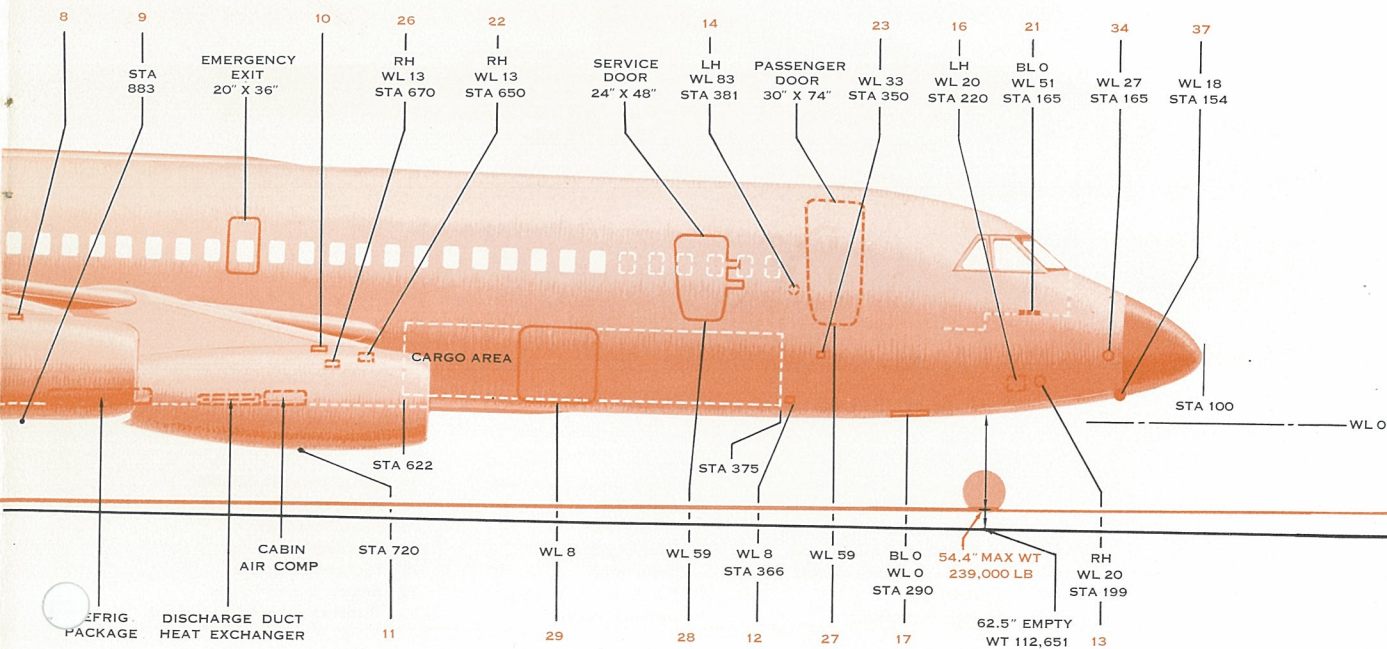
NOTE

Dimensions and stations on this page are to nearest inch, or nearest 1/4 foot, as indicated.

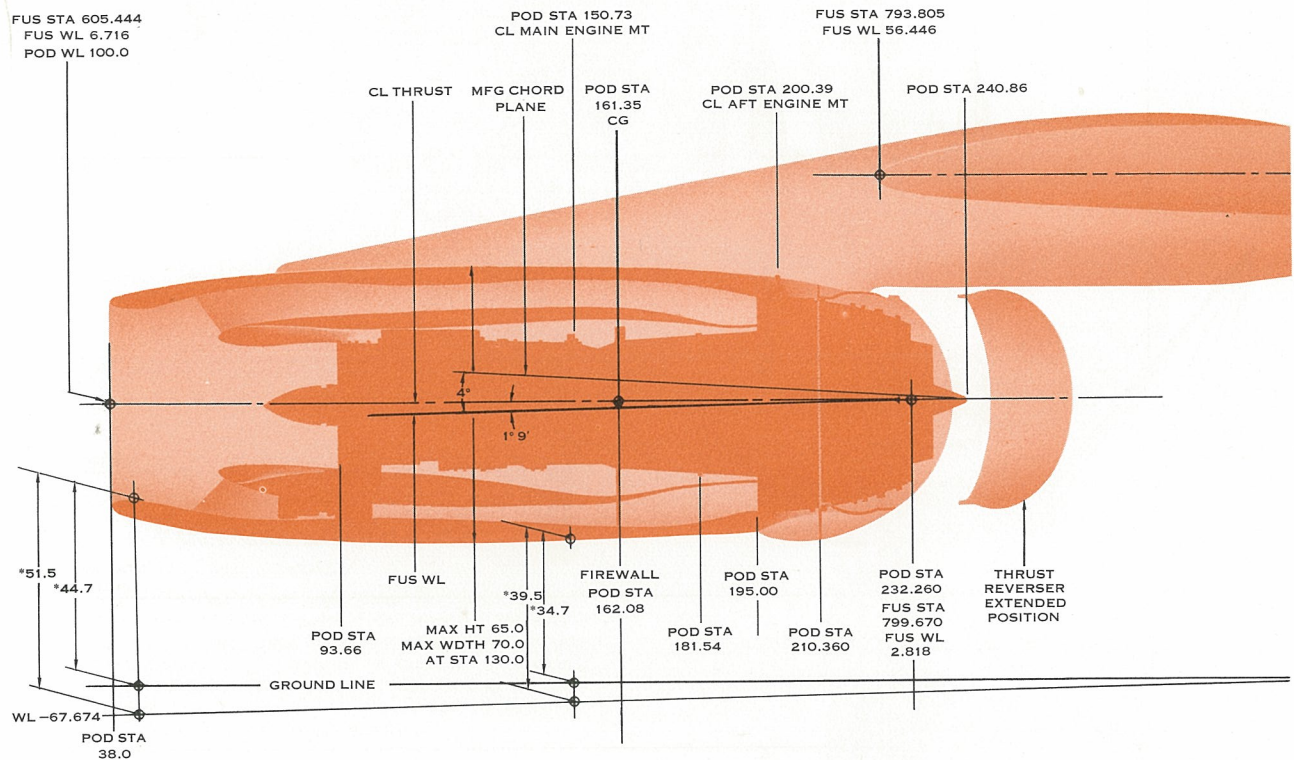


APPROXIMATE HEIGHTS FROM GROUND

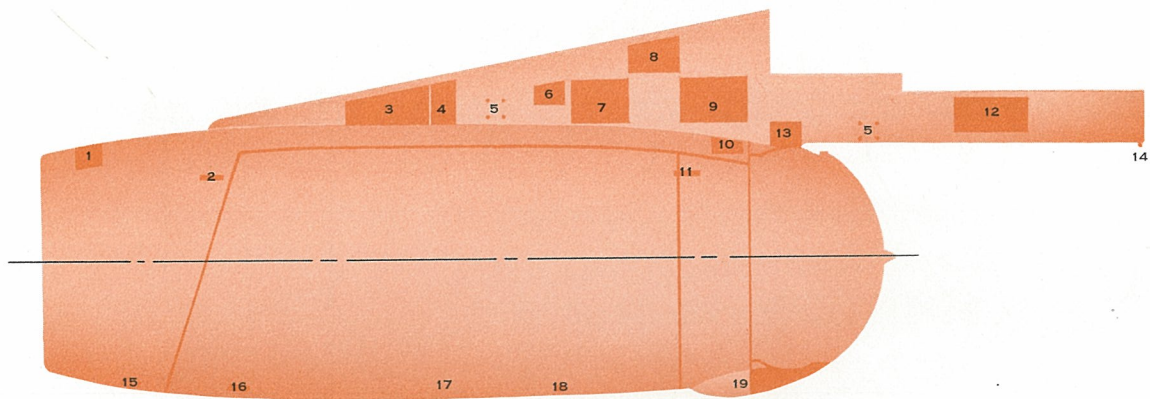
	EMPTY WT 112,651 LBS	MAXIMUM RAMP WT 239,000 LBS
1 Pressure refuel, bottom wing inbd	12'	11 1/4'
2 Pressure refuel, bottom wing outbd	12'	11 1/4'
3 Gravity refuel, top wing inbd	11'	10 1/2'
4 Gravity refuel, top wing outbd	13 3/4'	12 3/4'
5 Gravity refuel, anti-shock body inbd	11'	10 1/2'
6 Gravity refuel, anti-shock body outbd	12'	11 1/4'
7 Gravity refuel, center section	10'	9 1/2'
8 Engine & CSD oil, outbd pod	10'	9 1/4'
9 Lowest point, outbd pod	4 3/4'	4'
10 Engine & CSD oil, inbd pod	8 3/4'	8 1/4'
11 Lowest point, inbd pod	3 1/2'	2 3/4'
12 Main elec power recept	6'	5 1/2'
13 Nose elec power recept	7'	6 1/4'
14 Ramp elec recept - fwd	12 1/4'	11 3/4'
15 Ramp elec recept - aft	13 1/2'	13 1/2'
16 Elec equipment doors - LH & RH	7'	6 1/2'
17 Electronic equipment door	5 1/4'	4 3/4'
18 Hydraulic service points	7'	6 3/4'
19 Tail cone door - fwd	11 1/2'	11 1/2'
20 Tail cone door - aft	15 1/2'	15 1/2'
21 Nose wheel well top door	9 1/2'	8 3/4'
22 Water filler inlet	6 3/4'	6 1/4'
23 Lavatory service - fwd	8'	7 1/2'
24 Lavatory service - aft	9 1/4'	9 1/4'
25 Tail skid	10 1/2'	10 1/2'
26 Low-pressure air inlet	6 3/4'	6 1/4'
27 Passenger door floor - fwd	10 1/4'	9 3/4'
28 Service door floor - fwd	10 1/4'	9 3/4'
29 Cargo door floor - fwd compt	6 1/4'	5 3/4'
30 Cargo floor - aft large door	7'	6 3/4'
31 Wing tip trailing edge	14 1/4'	12 3/4'
32 Cargo floor - aft small door	7 1/2'	7 1/4'
33 Pass & Service door floor - aft	11 1/2'	11 1/2'
34 Pressurization grd test ftg	7 1/2'	6 3/4'
35 Fin tip trailing edge	39 1/2'	39 1/2'
36 Stabilizer tip trailing edge	18 1/2'	18 1/2'
37 Nose jack point	6 1/2'	5 3/4'
38 Wing jack points	9 1/4'	8 3/4'
39 Lowest point fuselage (Sta 910)	5 1/2'	5'



POD AND PYLON GEOMETRY AND STATIONS – INBOARD ENGINE

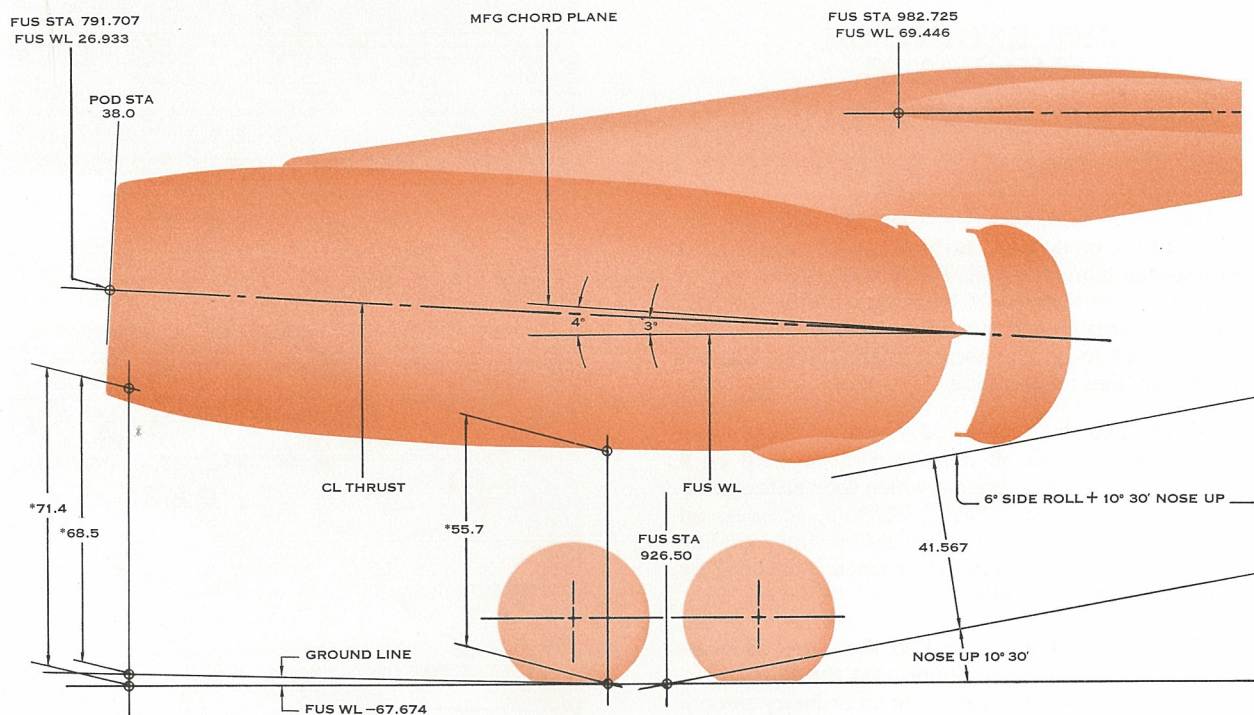


POD AND PYLON ACCESS DOORS AND PANELS – LEFT HAND SIDE



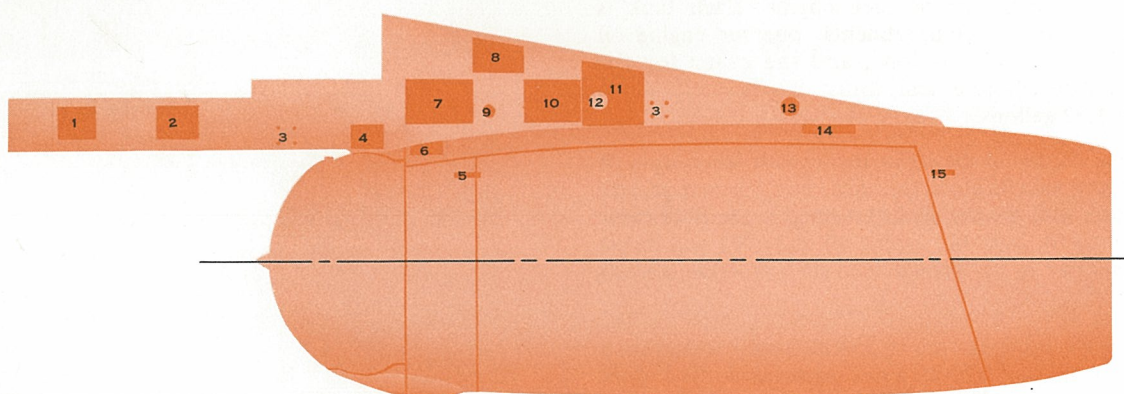
- | | | |
|--|---|-----------------------------------|
| 1 Ice detector, temp sensor, & anti-icing duct | 7 Bleed duct & fluid lines | 13 Thrust reverser actuator |
| 2 Shear latch | 8 Bleed duct | 14 Pylon drain |
| 3 Fluid & elec disconnects | 9 Fluid lines | 15 Interphone jack |
| 4 Hyd emergency shutoff valve | 10 Rear engine mount | 16 Fire door |
| 5 Hoist pad | 11 Shear latch | 17 Fuel control access |
| 6 Fluid line access | 12 Hyd filters, low pressure warning switch | 18 Engine & pylon drain |
| | | 19 Thrust reverser fairing, lower |

OUTBOARD ENGINE



RIGHT HAND SIDE

*JIG DIMENSION - NO PYLON OR WING DEFLECTION INCLUDED



- | | |
|--|-----------------------------------|
| 1 Elec harness & plumbing supports (inbd pylon only) | 7 Elec harness |
| 2 Side load fitting | 8 Bleed duct |
| 3 Hoist pad | 9 Frangible blowout disc |
| 4 Thrust reverser fairing, upper | 10 Bleed duct & elec lines |
| 5 Shear latch | 11 Fire ext bottle & check valves |
| 6 Rear engine mount | 12 Fire ext quantity gage |
| | 13 Engine oil quantity |

- | |
|----------------------------|
| 14 Engine & CSD oil filler |
| 15 Shear latch |

NOTE: The two outboard, or two inboard, pod-pylon assemblies are interchangeable. Inboard assemblies are not interchangeable with outboard.

JET ENGINE OIL MIL-L-7808C

One of the numerous requirements following the advent of the modern gas turbine engine was the need for a special lubricating oil. The new jet engine needed an oil with low viscosity at low temperatures and with a high viscosity index and low volatility. The oil was also required to be non-corrosive and have oxidation stability at high temperatures.

Existing petroleum base oil failed to meet these requirements, so the oil industry concentrated on a synthetic ester-based lubricant which showed the greatest promise. The result was a very thin, colorless oil combining the required characteristics and equaling or exceeding the military requirements covered by Specification MIL-L-7808.

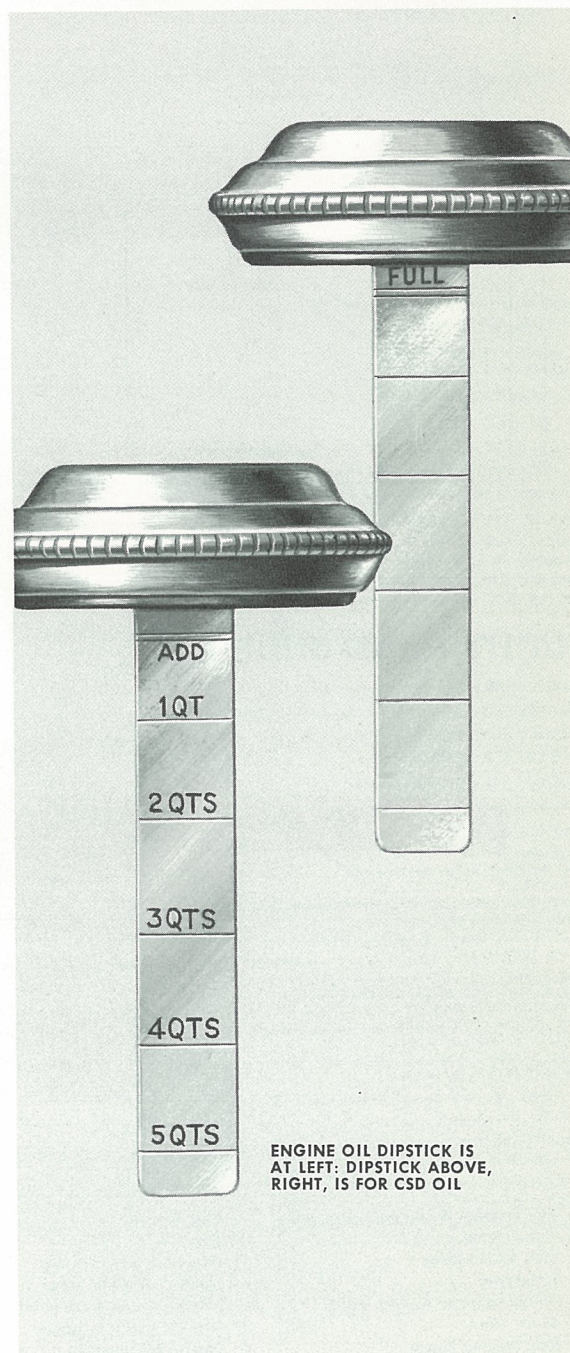
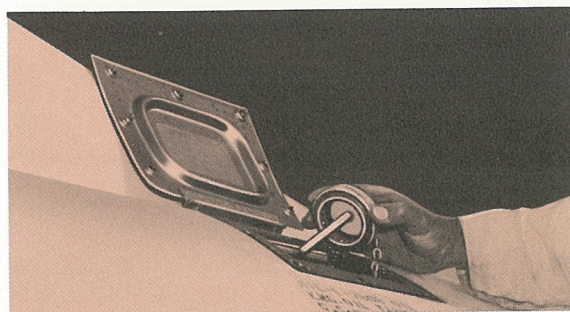
Convair engineers assigned to the lubrication aspects of the Convair 880 found that the thin, colorless oil was nearly indiscernible on an ordinary smooth dip stick. To overcome this difficulty, the engine oil and constant-speed-drive oil dip sticks are vapor blasted during manufacture to a satin or frosted finish. This provides the necessary noticeable contrast between the dry area of the dip stick and the oil-coated portion.

The Convair 880 has four engine oil tanks, one on the right hand side of each engine. Each tank is divided into two compartments: one for engine oil which holds 4.15 gallons, and the other for the constant-speed-drive and thrust reverser oil which holds 1.72 gallons.

Near the top of the tanks, through an access door in the upper nacelle quadrant, there are screened gravity fill ports with the dip sticks attached to the filler caps. Servicing for both the engine oil and CSD and thrust reverser oil is performed through the same nacelle door.

The oil dip sticks are approximately 3 inches long and are marked off in quart increments. The stick length is governed by the filler port screen depth which extends a little more than 3 inches below the port opening. The dip sticks are primarily used to facilitate oil tank servicing. The engine oil dip stick indicates oil level below full, down to 5 quarts and the CSD-thrust reverser oil dip stick indicates 1 quart plus.

Primary quantity gaging for the engine oil tank is accomplished by a capacitance probe in the tank with a readout in the flight compartment.



SAFETY WITH JET ENGINE FUELS

The most common types of jet fuels used in today's jet airliners are the kerosene-type fuels. Although the Convair 880/600 is capable of burning different fuels, ranging from high-grade aviation gasoline to straight kerosene, kerosene will probably remain the standard operating fuel for some time.

All personnel who are engaged in handling or working with kerosene jet fuel should be fully acquainted with its characteristics and make a habit of practicing a few simple safety rules. Kerosene is potentially dangerous and should be respected as such. Safety first can rule out injury and damage later on.

Kerosene fuel resembles gasoline and is either straw-colored or colorless. It is lighter in weight than is water; its vapors are heavier than air, and it is moderately volatile. A 1-to-6 percent kerosene vapor mixed with air forms an explosive mixture.

Mechanical shock does not ordinarily affect kerosene fuel. When mixed with liquid oxygen or other strong oxidizers, however, it forms a dangerously explosive mixture which can be set off by shock. A mixture of this type will also explode violently if exposed to a spark or open flame.

If mild concentrations of kerosene vapor are inhaled for more than 3 or 4 minutes, headache, dizziness, and nausea can result. Stronger fumes can anaesthetize, and prolonged inhalation can cause death. When taken internally, kerosene will have the same effects as inhalation with the added discomforts of burning and irritation of the mucous membranes.

It is not necessary to wear special clothing or equipment when handling kerosene fuel in well-ventilated areas. If clothes become soaked with kerosene, they should be removed immediately and any affected skin area should be washed with generous amounts of soap and water. The fuel will not affect the skin adversely if it is washed off quickly. If kerosene fuel should contact the eyes, they should be washed immediately with clean olive oil, castor oil, or water if oil is not available. In any event, prompt medical attention should be obtained.

Smoking should not be permitted in an area where kerosene fuel is being poured or transferred. When pouring the fuel from one container to another, the lip of one container should rest on the other, first making sure that the lower container is resting on a grounded surface. Keeping the two containers in contact during the entire transfer operation prevents the buildup of static charges of electricity during the pouring. As with other fuel, fire-fighting personnel and equipment



should be on a standby basis and readily available whenever kerosene fuel is being transferred.

Kerosene fuel storage containers, pipe lines, pumps, and related equipment must all be properly grounded and have adequate bonds across joints and flanged connections. Only nonsparking tools should be used in the fuel storage area, or when working around associated systems.

All cables, clips, braid, and other connections, used for grounding static electricity on fuel containers and handling equipment should be frequently inspected and kept in good condition. The maximum allowable resistance is 10 ohms between fuel tanks, tanks to ground, and nozzle to tank, when connected for filling or transfer operations.

Kerosene fuel storage containers, including cans, drums, or storage tanks, must all be kept tightly sealed to prevent excessive evaporation. At least 10 percent air space should be maintained in all storage vessels to allow for expansion.

The area where kerosene fuel is stored must be kept free of all combustible material to prevent fire spreading, should a fire occur. If fuel is spilled, the area should be flushed with quantities of water to dilute the concentration. If possible, spilled fuel should be collected in suitable containers and removed to a safe area where they can be burned or disposed of by other means.

Flushing and diluting liquid kerosene does not remove vapor concentrations. Since concentrations of kerosene vapor are more hazardous than is the fuel in liquid form, extreme caution must be exercised to ascertain that vapor concentrations have been dissipated.

Fuel clean-up rags should be quickly disposed of, as should the smallest quantities of kerosene fuel. If the fuel is allowed to soak into the ground, it remains for years as a potential danger where oxidizers are likely to be spilled.

Remember these safety rules when working with kerosene:

- Ground all equipment properly.

- Stop pumps when trouble occurs.

- Keep containers in contact with one another when transferring fuel.

- Keep storage area free of combustibles.

- Wear a breathing mask when entering tanks.

- Use only those lubricants, packing materials, and gaskets recommended by proper authority.

- DO NOT SMOKE!**

Operation Ice Hunt, to obtain FAA certification of the Convair 880 anti-icing system, began as a two- or three-day jaunt to Seattle, Washington. Because of the "unfavorable" weather conditions in the Seattle area, the airplane was flown into the far Alaskan Northland in search of weather that would "trigger" the ice sensing probes. Many hours were spent high above the frozen wastes of Alaska, waiting for Mother Nature to dish up her worst kind of weather. When it came, the "880" traced and retraced its course through the storm condition, at low speed to produce maximum icing. Every conceivable test condition was tried to let ice build up. The system and airplane emerged victorious over the icing conditions encountered.

24 10

The photo snapped from the window of the "880" shows some Alaskan scenery viewed on the flight.



CONVAIR SAN DIEGO

CONVAIR DIVISION

GENERAL DYNAMICS CORPORATION

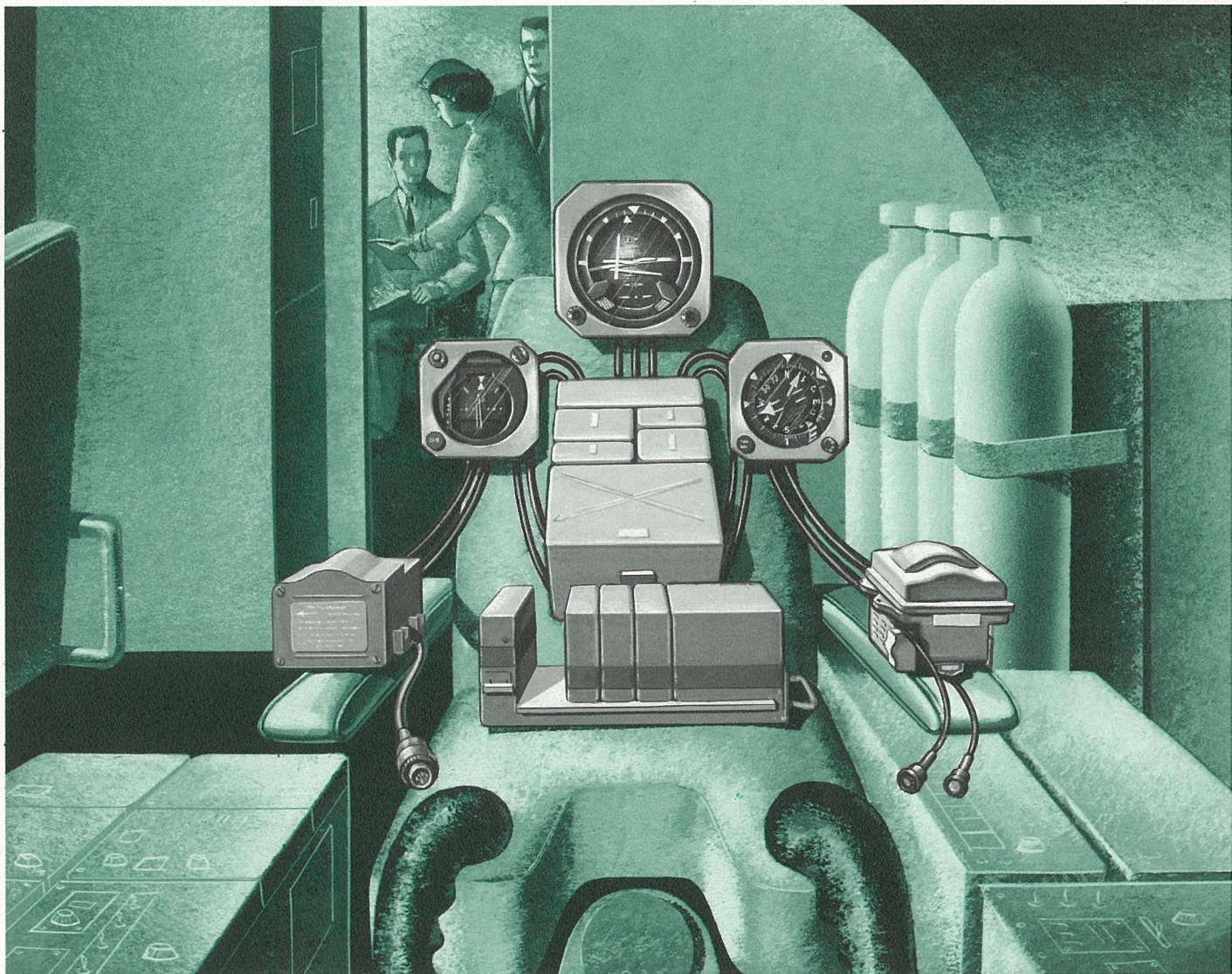
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Convair **Traveler**

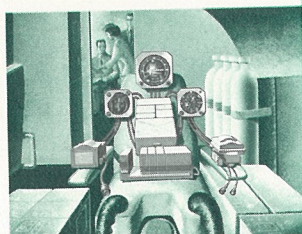
11 44



In this Issue: Sperry Instrument and Autopilot Systems

VOLUME XII NUMBER 2 JUNE 1960

Convair Traveler



In this Issue: Sperry Instrument and Autopilot Systems

OUR COVER

Autopilots are not licensed for ground operations, including hangar flying and takeoff. But en route they're unbeatable; they hold course, execute smooth turns and neat approaches, and fly equally well under VFR or IFR. Pilot portrait is by Norm Harrington and Tony Adams.

Convair Traveler

VOLUME XII NUMBER 2 JUNE 1960

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IN THIS ISSUE

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SPERRY INSTRUMENT
& AUTOPILOT SYSTEMS
880/600

Hugh R. Smith

PAGE 11

ENGINE AIR INLET
VORTEX DESTROYER

Sam Urshan

Back Cover

CJ805-3
SECTIONALIZED OVERHAUL

Hugh R. Smith

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Sperry Instrument & Autopilot Systems

Convair 880 and 600

Three versions of Convair 880 and 600 aircraft are equipped with Sperry integrated flight and navigation instruments and the SP-30 autopilot. The behind-the-scenes components—radio receivers, compass and accelerational sensors, electronic modules, and servos—are for the most part identical or closely similar, although some systems have more elements than others.

In all versions, autopilot operation provides for 1) yaw damping and turn coordination, under either full manual or autopilot control; 2) for straight and level flight under gyroscopic attitude or barometric altitude control as desired; 3) for automatic interception and following of VOR radials or ILS localizers; and 4) for automatic glide path engagement.

The instruments provide airplane attitude and compass bearing, bearings to ADF and VOR stations, and deviation bars to show airplane position relative to radio beams and stations. There are available, however, a number of instrument and control panel configurations. Customer preferences have varied enough to result in some immediately apparent differences in the pilots' instruments and the autopilot control panels.

To prevent confusing the systems in these three versions of the Convair jet airliners, the navigation instruments and autopilot of the "880" Model 22-2 will be described first. They are typical of the Sperry installations; the other two may then be compared with particular reference to their differences.

Integrated Instrument System

"880" MODEL 22-2

There are three basic instruments in the Sperry integrated flight instrument system: the C-6 Gyrosyn compass indicator, the HZ-4 attitude indicator, and the R-1 pictorial deviation indicator. A fourth indicator—the RMI, or Radio Magnetic Indicator (not a Sperry unit)—may be included among the navigation instruments.

The RMI need not be discussed in detail, since it is a standard instrument now familiar to most transport pilots. It has a rotating compass card governed by the compass system, and two pointers controlled by the two ADF low-frequency receivers. It will simultaneously give airplane heading and bearings of two selected low-frequency broadcast stations. The marker beacon light installation is also typical.

The RMI is mounted at the right-hand side of pilot's and copilot's instrument panels; marker beacon lights are just above it. The other three navigation instruments are at panel center, with the attitude indicator at the top, the compass below it, and the pictorial deviation indicator to the left of the compass.

The C-6 compass indicator at first glance resembles the RMI, with two RMI pointers in addition to the azimuth card. These pointers, however, operate in conjunction with the VHF receivers and hence will give bearings of VOR stations tuned in. The instrument has command functions (preselect heading) in connection with the autopilot, which will be taken up later herein.

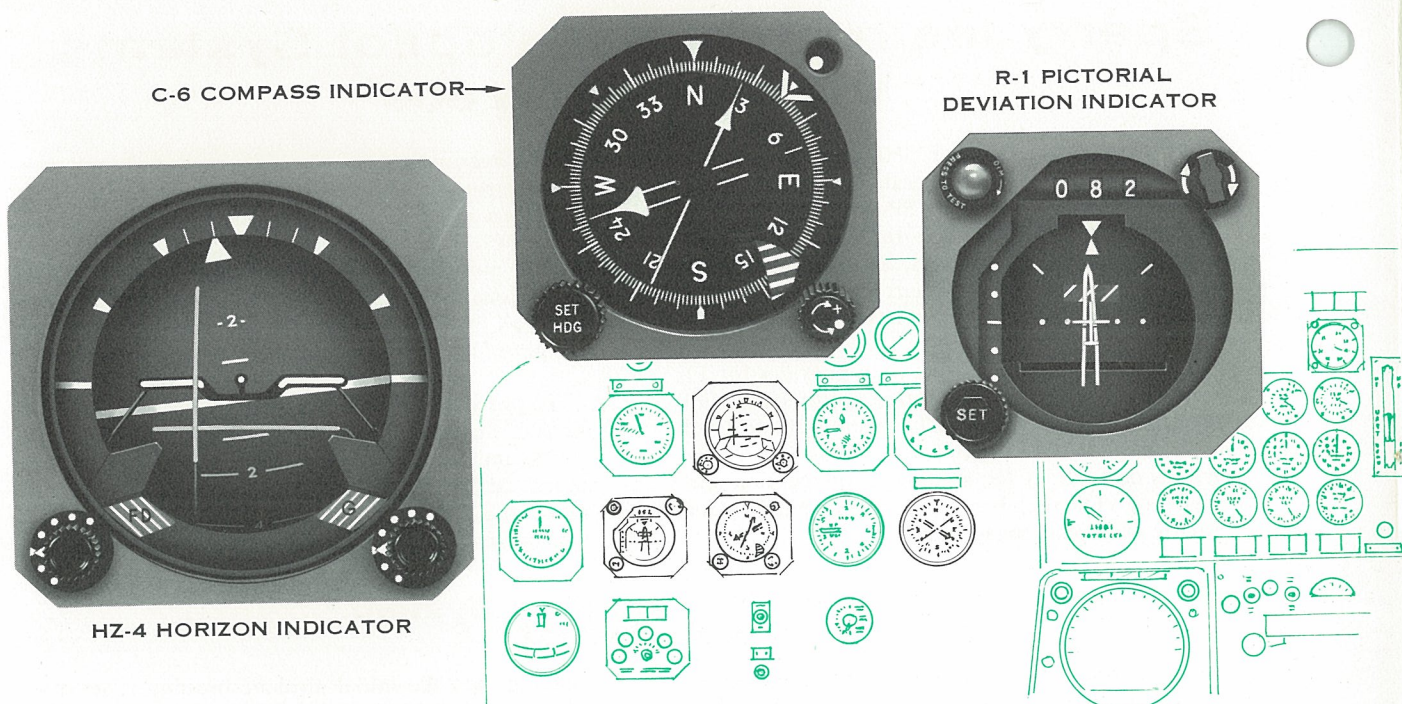
Compass and RMI azimuth cards are controlled by the C-10 compass systems. There are two complete systems and, as in most Convair aircraft, pilot and copilot panels have indicators for both systems. The pilot's compass indicator and copilot's RMI are controlled by one system, copilot's compass and pilot's RMI by the other.

The compass has two modes, slaved magnetic and free gyro, selected by switches on the pilots' panels. In free gyro mode, the directional gyro maintains any

heading, and the initial airplane heading is set manually on the dial by means of the synchronizing knob at the lower right-hand corner of the instrument. Gyro control provides a very accurate reference over short distances and may be used for grid navigation in polar regions. Random drift is held to a maximum of 3° per hour. Since this version of the "880" will be operating chiefly in lower latitudes, no latitude correction has been provided.

In slaved mode, the compass is still gyro stabilized. Actual gyro axis direction is of no importance; the magnetic heading and the gyro heading are synchronized either automatically or manually by rotating the indicator azimuth card. The magnetic sensor, a flux valve in the right wing tip, transmits its signal to a synchro in the instrument, rather than to the gyro unit. Any discrepancy between magnetic heading and that shown on the gyro-driven azimuth card will cause a small cross or dot to appear in an annunciator window in the upper right corner of the instrument. By turning the "sync" knob in the direction indicated by the annunciator, the card can be rapidly rotated until the window clears. Thereafter, any wandering of the gyro from magnetic heading will be corrected by slow slaving (1° to 2° per minute) of the gyro to the flux valve heading, via a signal from the instrument.

The horizon indicator, in "880" Model 22-2, has no command functions, and the vertical and horizontal bars that are visible when power is off are biased out of sight after the vertical gyro erection is completed. The dial shows a black sphere with a white horizon line; the sphere rotates in both roll and pitch axes. Short horizontal lines above and below the horizon line can be read against a reference airplane, to indicate pitch angle; each line represents 10° nose-up or nose-down attitude. A roll index at the top is read against a pointer to show roll angle. Vertical gyro power failure will be indicated by a flag in the indicator.



The R-1 pictorial deviation indicator provides a representation of the airplane position with respect to a selected VOR radial or to an ILS localizer beam and glide slope. It includes course selection for the autopilot, mode indication, and warning flags.

When a VOR station is tuned in, the inbound bearing of the desired radial is selected by means of the SET knob; the bearing appears in a digital counter at the top of the instrument. A wedge pointer (V) appears on the dial, pointing along the radial toward the station, at an angle that represents the direction of the beam relative to the airplane heading. The "V" bar displacement from a fixed reference airplane symbol indicates the position of the airplane relative to the beam, and to the station.

As the airplane passes over the station and encounters the radio signal beyond the zone of confusion, a to-from sensor will rotate the "V" bar 180°. The pilot may prefer to set the outbound radial on the counter; if so, he may do so by using the reciprocal heading knob, on the upper right of the instrument. The digital counter will then indicate the outbound VOR radial bearing but the direction of the "V" bar will remain unchanged. The instrument will not give a false to-from reading in VOR operation; whatever course is selected, the "V" bar always points to the station.

In ILS operation, the course counter is set on the runway inbound bearing. The localizer is a single-direction signal and no to-from signal is available. Therefore the "V" will not invert even though the airplane passes over the localizer station. When a glide path signal is received, a glide slope bar appears and is deflected up or down from center to show the deviation of the airplane relative to the glide path.

Near the base of the "V" bar a window shows a flag with three positions, OFF, VOR, and LOC. The LOC

flag is blue-yellow; the blue half will be on the right in normal approach. Should the airplane fly over and on past the runway, course setting should be left unchanged for go-around. The blue-yellow indication and "V" bar will remain as before. When the airplane makes the 180° turn, the "V" bar, being azimuth stabilized, will invert and be displaced toward the beam; the blue-yellow flag will swing around to the top of the dial, so that the blue indication will be on the left, emphasizing that the airplane is now on a reciprocal course. As the airplane turns again into the localizer beam, the "V" bar and blue-yellow flag will resume the normal approach pattern.

In event of compass malfunction, the R-1 can be used as a left-right deviation indicator by pulling out the SET knob and rotating the "V" bar until it points

A	ELEVATOR SERVO
B	RUDDER SERVO
C	AILERON SERVO
D	AFT PITCH ACCELEROMETER
E	AFT YAW ACCELEROMETER
F	LOWER ROLL ACCELEROMETER
G	UPPER ROLL ACCELEROMETER
H	STABILIZATION COMPUTER
J	FWD PITCH ACCELEROMETER
K	VERTICAL GYRO
L	FLIGHT CONTROL COMPUTER
M	FWD YAW ACCELEROMETER
N	TRIM SERVO
P	AUTOMATIC PILOT CONTROLLER
Q	YAW DAMPER TESTER
R	AUTOPILOT INDICATOR

vertically. This disengages the compass servo system and leaves the pointer in a vertical position, functioning as a simple right-left deviation bar.

Loss of radio signal will cause the VOR-LOC flag to indicate OFF. A glide slope warning flag marks loss of the glide slope signal.

SP-30 Automatic Pilot

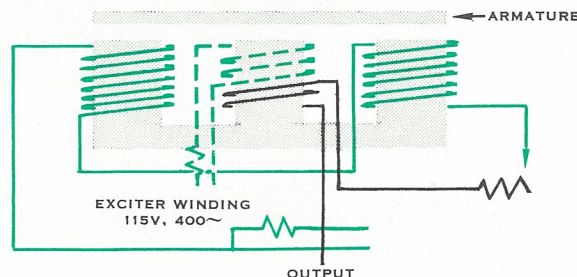
"880" MODEL 22-2

The SP-30 autopilot has four types of components (cockpit controls, electronics assemblies, servos, and sensors) arranged in the airframe as shown in the accompanying figure. In the flight compartment are the controller, indicator, and yaw damper tester. The controller, on the center pedestal, provides for autopilot engagement and mode switching. The indicator, on the instrument panel, contains autopilot trim meters and warning lights. The yaw damper tester, also on the instrument panel, provides a rapid preflight test of the airplane's yaw damper mode. The two electronic components — the flight control computer and stabilization computer — are located in the electronics compartment. There are three servos for the primary flight controls, plus a separate elevator trim servo.

The inertial sensors consist of the vertical gyro and six accelerometers. The vertical gyro is a conventional electrically-driven gyroscope that establishes roll and pitch displacement reference for both instrument system and autopilot.

The acceleration sensors are distinctive features of the SP-30 autopilot. There are six linear accelerometers, two for each airplane axis, taking the place of rate gyros. Each accelerometer is a simple and rugged transducer, weighing approximately 12 ounces. Essentially, it consists of an E-pickoff transformer and a leafspring-suspended armature, which acts as an inertial mass and also forms a path for magnetic flux. The E-shaped core of the transformer contains an excitation winding on the center leg and a signal-output

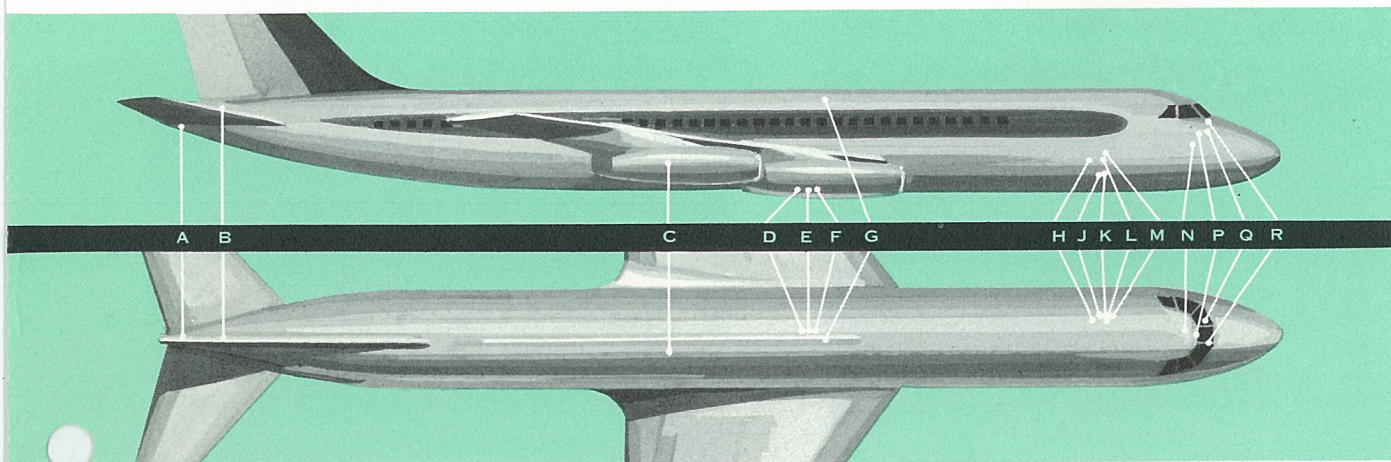
SCHEMATIC OF ACCELEROMETER



winding on each outer leg. Output windings are differentially connected to yield a null output under static conditions. Inertia of the suspended armature causes it to move under acceleration load, in the directions in which it is free to move. This varies the reluctance of the magnetic circuit, producing a signal in the output windings proportioned to acceleration rate.

For example, a vertically-oriented accelerometer near the airplane center of gravity yields a signal that is proportional to vertical acceleration of the airplane. When a second accelerometer is placed near the airplane nose and is oriented in the same direction, the electrical difference between the two signals is a measure of pitch angular acceleration. Yaw axis accelerometers are similarly located, but are oriented to measure lateral and yaw accelerations. Roll axis accelerometers, separated in a vertical plane, are both mounted near the CG at top and bottom of the fuselage.

Use of inertial stabilization, the Sperry Company maintains, provides quick response to gusts and tighter control of heading, attitude, and flight path. It makes possible a servo system with a high-torque gradient. The servo system employs both aircraft angular acceleration and servo tachometer data for feedback to close the servo loop. This permits the SP-30 to provide automatic gain adjustment of its control signals over the airplane's airspeed range, since variation in control surface effectiveness is compensated through the feedback from acceleration sensors.



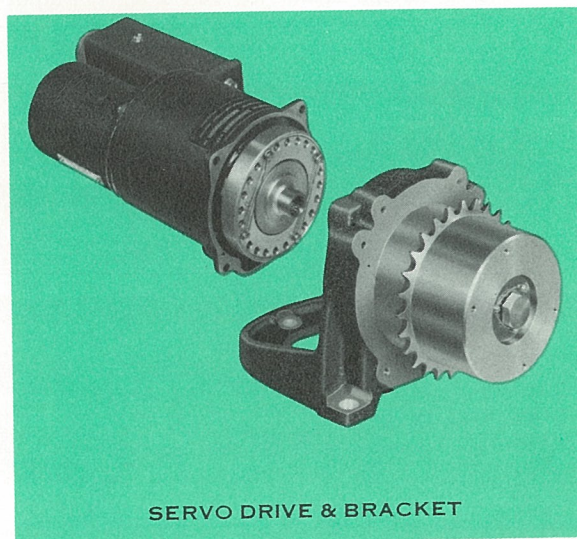
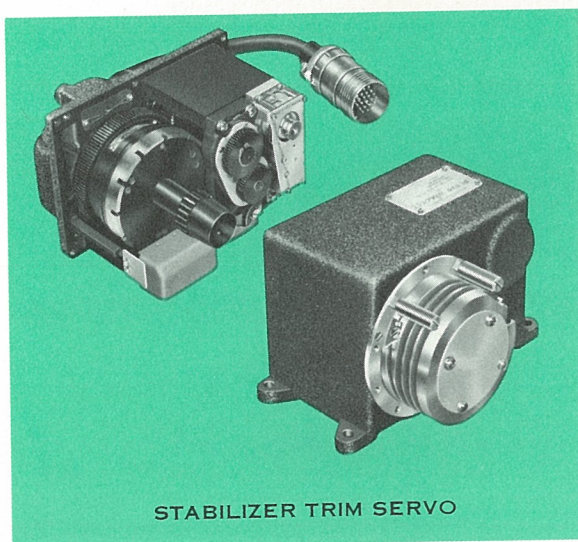
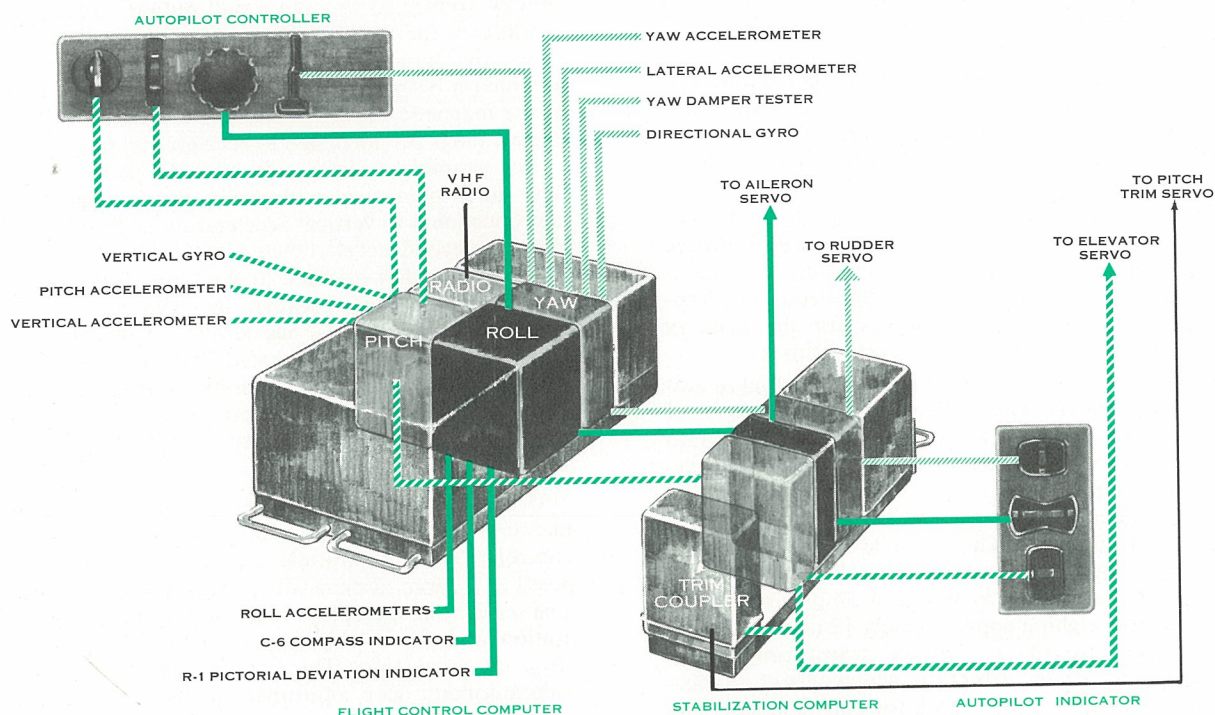
The "brain" of the SP-30 is the flight control computer, which collects data from the sensing and feedback elements and receives the command signals from the flight compartment and radio controls. It consists of a relay assembly, gain calibrator, and five plug-in modules.

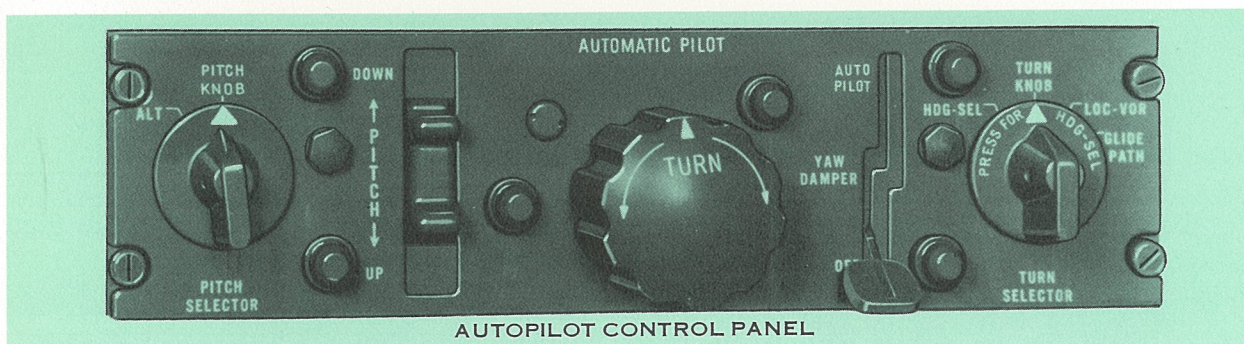
Each axis—yaw, pitch, and roll—of the automatic pilot is provided with an individual plug-in command computer. These computers are composed of several "building-block" amplifier-shaping circuits and an electromechanical followup element. A fourth

plug-in module is the pressure computer, to provide reference signals for constant altitude control. The altitude control unit is connected to pitot-static sources. A three-position pressure switch, sensitive to three ranges of pitot-static differential, controls autopilot parameters as a function of airspeed.

The fifth module is a radio coupler, to supply attitude-command signals to pitch and roll computers in accordance with radio beam data supplied by VOR and glide slope navigation receivers. The gain calibrator adapts the gains of the autopilot signals to the

AUTOMATIC PILOT SYSTEM





specific requirements of the "880" and "600" aircraft, permitting interchangeability of other system components.

Signals from the flight control computer are amplified in a stabilization computer to drive the servos. The stabilization computer is also a plug-in modular unit, with three identical servo amplifiers, one for each axis, and an automatic cutoff.

The automatic cutoff continuously monitors SP-30 operation in roll and pitch axes by comparing signals from the accelerometers, vertical gyro, servo system input, and servo tachometers. It protects against unwarranted or excessive servo effect produced by failure in either of these axes. The yaw axis is not monitored during flight, but may be checked prior to flight by use of the yaw damper tester (optional equipment).

Two parts comprise the primary servo unit in each axis: a bracket, containing a cable drum and shaft; and a drive assembly consisting of a split-field dc series motor and tachometer assembly, a power gear train, and a clutch, splined to the servo bracket. The clutch is tooth type, being engaged by flexing rather than sliding action. The teeth are wide-angled, and the clutch is capable of being overridden by 150 to 200 percent of normal force applied on the control column. The horizontal stabilizer servo serves to relieve heavy trim loads in the elevator servo system.

The autopilot controller in the flight compartment is mounted on the pedestal between the pilots. The main servos-engage switch, to the right of panel center, has a visible detent at midpoint to engage the yaw damper, and is pushed on up to engage the autopilot.

Yaw damping supplements normal pilot control with automatic rudder action to damp out "Dutch roll" tendencies and provide coordination during turns. AUTOPILOT position of the switch engages rudder, elevator, and aileron servos to maintain three-axis control.

At left on the controller panel is the PITCH SELECTOR switch. PITCH KNOB position is essentially an "off" position for altitude hold, allowing pitch rate commands to be set in with the PITCH knob. When the pitch selector is at ALT, the pressure computer will hold the airplane at the altitude where the switch was engaged.

At the right of the panel is the TURN SELECTOR rotary switch for selection of four modes of operation. They are as follows:

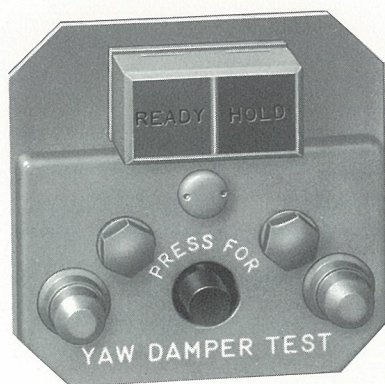
1. TURN KNOB position is a mode that in other installations has been termed "manual" or "attitude hold." The autopilot will maintain the airplane in straight and level flight under command of the directional and vertical gyros. Coordinated turns can be made by use of the TURN knob at panel center, within a 35° bank angle limitation. Pitch maneuvers with the PITCH knob are limited to $\pm 15^\circ$ pitch angle. Center position of the TURN knob has a detent, with a definite snap action as the knob is rotated from center. It is not self-centering, and must be returned to detent to bring the airplane back to wings-level. The PITCH knob is self-centering when released; it returns to neutral, and the airplane remains in the attitude existing upon release.

2. HDG-SEL mode is for following a compass heading preselected by means of the SET HDG knob on the C-6 compass indicator. The knob drives an index on the circumference of the compass card to the chosen heading and, on actuation of the autopilot mode switch, the autopilot will turn the airplane into the heading and maintain it there.

3. LOC-VOR mode is for interception and following of omnirange and ILS localizer radio beams. In VOR operation, the omniradial heading is set on the R-1 deviation indicator with the SET knob. The VHF navigation radio is tuned to the desired VOR or ILS frequency, and the beam approached at any angle under 90°. When the selector switch is turned to LOC-VOR, if the signal is above the minimum strength required for autopilot operation, the airplane will automatically approach the localizer beam or VOR radial and follow it. In ILS operation, the inbound heading may be set on the R-1 to monitor the approach pictorially; but, the autopilot is under direct radio control and will follow the localizer beam regardless of R-1 setting.

4. GLIDE PATH mode permits automatic approach to the glide path along the localizer beam, and automatic engagement and following of the glide path down as far as the pilot wishes to go under automatic control.

Two options are provided for manual disengagement of the autopilot. The servos-engage switch can be pulled back to YAW DAMPER, leaving yaw damping engaged, or to OFF, disengaging the yaw damper also. When this is done, an AUTOPILOT OFF warning light on the pilot's panel illuminates. Also, on each pilot's control wheel is an AUTOPILOT OFF release



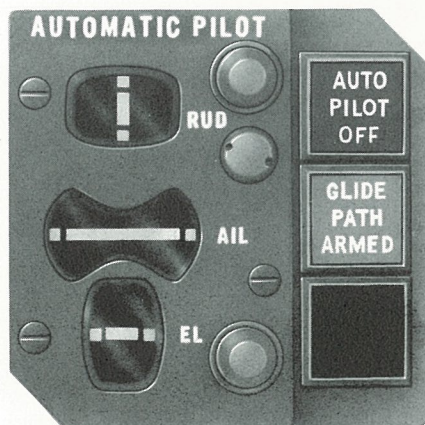
YAW DAMPER TESTER

button, which returns the servos-engage switch to OFF without illuminating the warning light. If the engage switch is used to cut off the autopilot, the warning light can be extinguished by using the control wheel release button. The engage switch is a positive, "make-before-break" type which will always disengage the autopilot.

Electrical interlocks give command priority to the TURN and PITCH knobs on the autopilot controller. Altitude control and glide path modes are instantly canceled when the PITCH knob is displaced from center. Preselected heading control, localizer, or omnirange control modes are canceled when the TURN knob is moved from center detent.

The yaw damper tester is a built-in ground test circuit that transmits signals to the yaw damper system to simulate airplane yaw acceleration. A single push-button operates the assembly; a double light assembly indicates HOLD if the yaw damper system is malfunctioning, or READY if it is operating normally.

The autopilot indicator, on the center instrument panel, has three trim meters to give visual indications of rudder, aileron, and elevator servo trim conditions. At right of the trim indicators are the AUTOPILOT OFF warning red light, an amber GLIDE PATH ARMED light to show that the glide slope signal is being received, and an amber AUTO TRIM OFF light to indicate pitch trim malfunction. The glide path light extinguishes when the glide path is engaged.



AUTOPILOT INDICATOR

Flight Director & Autopilot

"600" MODEL 30-6

The principal difference between the Convair 600 Model 30-6 instrument system and that previously described is that this airplane has flight director components in the system.

The flight director gives the pilot a means of achieving increased accuracy in omnirange flying, approaches, and precise maintenance of heading and attitude. The system operates in conjunction with a flight director computer and the vertical and horizontal command bars in the HZ-4 horizon indicator.

Where standard deviation-bar indicators show relative displacement of the airplane from a projected flight path, the command bars, under computer control, show the proper action to be taken for flying a heading or course. Deviation bars would be centered when the airplane is on the desired flight path, regardless of its attitude; the HZ-4 command bars are centered when the airplane is in the proper attitude for flying to or maintaining a path.

A six-position selector switch determines the mode in which the system will operate. The switch positions are as follows:

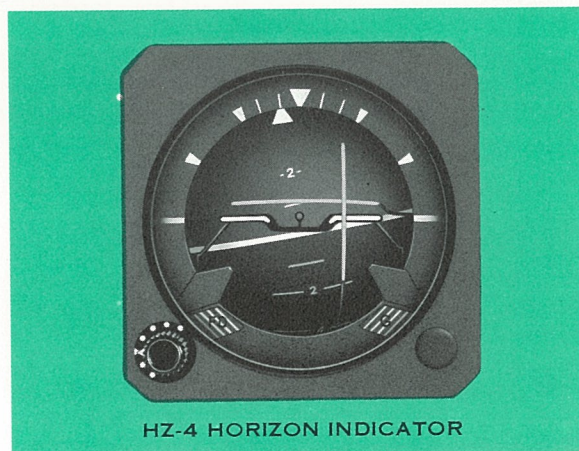
SB — standby, in which the command bars are biased out of view, with the HZ-4 merely a horizon indicator.

BL — blue left, for flying a back-beam approach to a localizer.

FI — flight instrument, in which the vertical command bar is referenced to the heading set on the C-6 compass by the SET HDG knob.

VOR-LOC — omnirange-localizer, for flying to and along a VOR radial or ILS localizer beam. The radial or ILS runway inbound bearing must be set on the R-1 pictorial deviation indicator by the SET knob and will show in the digital counter on the R-1.

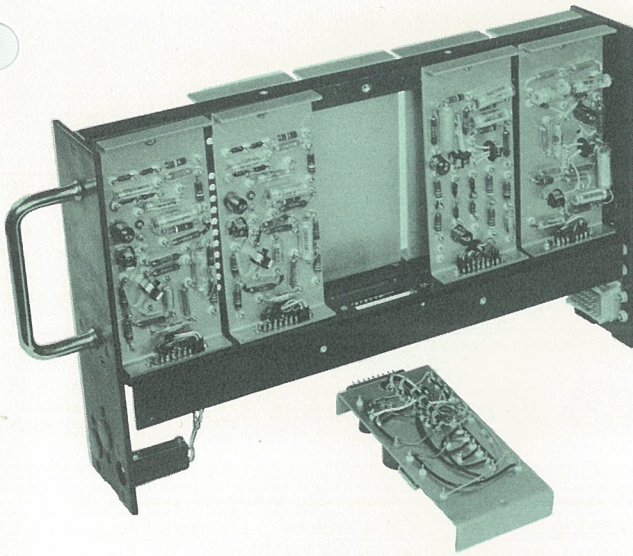
APP — approach mode, in which computed glide slope information is displayed on the horizontal command bar.



HZ-4 HORIZON INDICATOR

Flight Director & Autopilot

"600" MODEL 30-5



FLIGHT DIRECTOR COMPUTER

GA — go-around, in which the horizontal bar is biased upward to command a predetermined climb-out attitude and the aircraft heading at the time of switching becomes the vertical bar computed climb-out heading.

In BL, FI, and VOR-LOC modes, the horizontal bar displays computed signals to maintain the proper commands for level flight. There is no flight director mode for altitude hold in this installation.

In all modes, "flying to the needle" so as to keep the command bars centered will cause the airplane to turn toward the selected heading or course, approach it asymptotically, and fly along it. In flying radio beams, as with autopilot operation, wind correction will be automatic.

The Model 30-6 autopilot differs from that already described in two particulars: this airplane does not have the yaw damper tester; and the elevator trim mechanism is hydraulic rather than electric, so that autopilot trim operates by solenoid valves rather than by a servo motor.

The Convair 600 Model 30-5 differs markedly from the two versions previously described in instrument configuration.

The changes have the effect of making the indicators, autopilot control panel, and some operational characteristics somewhat resemble the Bendix Series 200 flight director and PB-20 autopilot systems. However, since the components are Sperry, the instrumentation is not identical with the Bendix flight director indication.

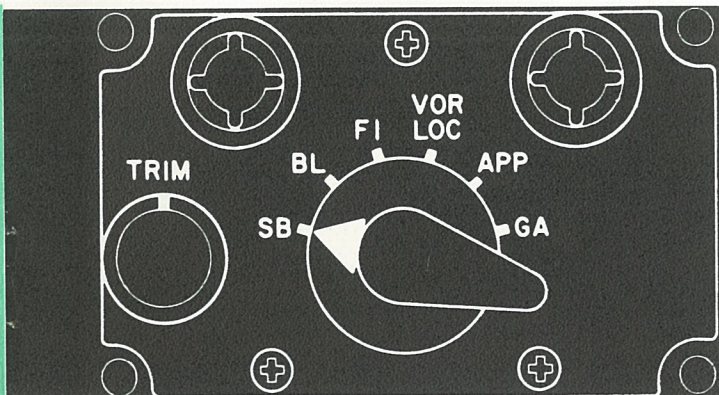
Each pilot's instrument panel display has a horizon director indicator at the center top position; a course deviation indicator under it; and a radio magnetic direction indicator to the right of the course deviation indicator. In the lower right-hand corner of the pilot's panel are switches for flight director mode selection and for compass systems.

The compass systems are the Sperry C-10, already described herein. Compass indications appear on both the radio magnetic direction indicator (RMDI) and the course deviation indicator (CDI), on rotating compass cards with lubber lines at the top.

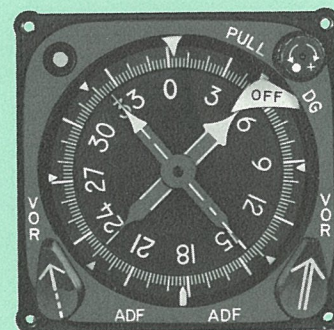
The RMDI is the primary compass indicator; the CDI azimuth card is slaved to it. An annunciator for aligning the gyro and flux valves appears in the upper left corner of the RMDI; the synchronizing knob is in the upper right corner. The slaving mechanism is similar to that previously described. The "sync" knob may be pulled out to allow free gyro control of the compass cards.

The RMDI has two conventional radio directional needles, showing bearings of two selected ADF stations, two VOR stations, or one of each. Switches at the lower corners of the instrument are used to control selection between ADF and VOR receivers.

The CDI has, inside the azimuth card, a radio-beam directional and deviation bar, showing lateral and angular displacement of the airplane from the localizer beam center or from the VOR radial selected. A to-



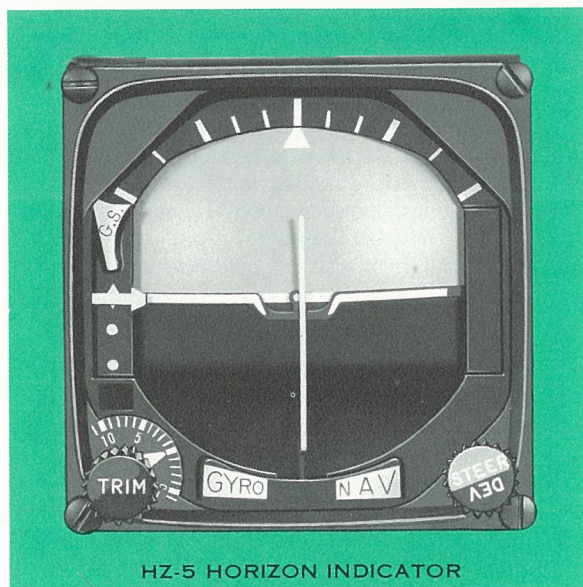
MODE SELECTOR FLIGHT DIRECTOR SYSTEM



C-6E COMPASS INDICATOR

from arrowhead shows relative position of VOR stations.

A knob at lower left sets a course for flight director system or autopilot use, by positioning an inverted T cursor on the azimuth card, and simultaneously shows the bearing in a digital counter at upper left on the instrument face. Preselect heading, for flight director or autopilot, is set by the knob at lower right, which positions a heading cursor on the azimuth card. The CDI has a horizontal glide slope deviation bar, which is always biased out of view in this installation. In emergency loss of compass signal, pulling the course knob out allows the azimuth card to be rotated until the deviation bar is vertical; it then may be followed as if it were a simple left-right deviation bar, so that the airplane can be flown to a radio beam without reference to compass heading.



HZ-5 HORIZON INDICATOR

The horizon director indicator (HDI) shows a disk, of which the upper half is blue and the lower half black, to indicate roll attitude. Since it is a disk and not a sphere, it does not show pitch angle; this is shown by a "servoed" miniature aircraft which moves up and down within a plus or minus 34° pitch attitude range. The miniature aircraft may be trimmed by the knob at lower left.

To the left of the horizon disk is a glide slope display consisting of a vertical row of dots and a short horizontal glide slope bar.

A deviation-command steering needle, pivoted at the bottom of the dial, is displaced from vertical, left or right, in response either to signals from the VHF radio receivers, or to computer signals combining roll, heading, and radio information. At the lower right is a DEV-STEER knob having two positions, 180° apart. When the DEV lettering is uppermost, the needle shows relative distance and the general left-right direction of VOR/ILS beams.

When the knob is rotated to STEER position, the steering needle is under control of the flight computer.



R-4B COURSE DEVIATION INDICATOR

If computer input is from the compass system, the steering needle deflection will be a command to turn toward the heading set on the CDI by the heading select knob. As the pilot enters into a turn toward the needle, it will center; by keeping it centered, the pilot will level out on the heading chosen.

If computer input is from the VHF radio, the needle deflection will command a turn toward the VOR radial or localizer beam center, on a course set on the CDI by the course select knob. By flying to the needle, the pilot will approach the beam asymptotically.

Summarizing: (1) Compass heading appears on the RMDI and CDI. (2) Radio course deviation appears on the CDI, and on the HDI when the knob is in DEV position. Glide slope deviation appears on the HDI. (3) Preselect heading and course are set into the CDI. (4) When the HDI knob is in STEER position, directional commands from the computer govern the steering needle, to aid in approaching and maintaining magnetic or VOR/ILS courses. (5) The command system does not function in connection with pitch attitude, either for glide slope or for altitude hold.

The autopilot controller panel differs from the standard Sperry installation. The altitude hold control is a toggle switch rather than a knob. One reset button has been added for the AUTOPILOT OFF warning light. On the mode selector switch, the terms HDG SEL and TURN KNOB have been replaced by HDG and MAN respectively, but the functions of the autopilot in these positions are unchanged.

Heading and course for HDG and VOR-LOC modes are set on the CDI. The trim indicator, at upper right on the instrument panel, is similar to that previously described. There is no yaw damper tester in this installation, and elevator trim is hydraulic, as in the Model 30-6 installation.

One difference in the autopilot-off warning system may be noted: When the autopilot is turned off by any means — automatically, by the engage lever, or by the release buttons on the control column — the AUTOPILOT OFF light on the panel will illuminate, as will a light in the reset button on the autopilot controller panel. Pressing the reset button will then extinguish both lights.

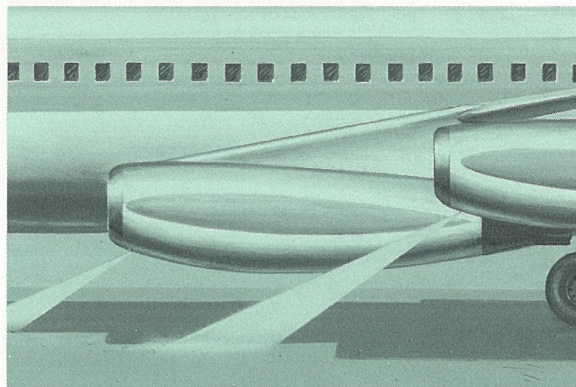
Engine Air Inlet Vortex Destroyer

Prevents formation of miniature tornado to protect engine inlets from ingesting runway debris

The engine air inlet vortex, a phenomenon resembling a miniature tornado, can possibly form between the engine air inlet and the ground when the Convair 880 engines are operated on the ground. This vortex, with its swirling pattern, creates a strong suction force that is capable of lifting small foreign objects from the runway. If this vortex is not destroyed, it is possible that runway debris could subsequently enter the engine with damaging results.

To prevent a vortex from forming and thereby minimize ingestion of foreign material into the CJ805 engines during ground runs, a jet airstream nozzle is incorporated in the lower leading edge of the nose cowl of each engine just aft of the anti-iced section. The jet blast is directed from the nose cowl downward toward the ground where the vortex base can generate between the ground and the engine air inlet.

The inlet vortex destroyer system utilizes engine bleed air and is controlled by a shutoff valve, located in the nose cowl. The control valve is a two-position (open-close) valve that is opened by a signal from either one of the two landing gear safety switches, located on the left and right main gear scissors. It closes when the weight of the aircraft is removed from the main landing gear.



The two switches, which determine the open or close position of the vortex control valve, are series-wired with the generator load-limit switch, which completes the circuit when the engine is running at idle rpm. In other words, if the airplane is on the ground with engines inoperative, the main landing gear safety switches will be closed, but only half of the circuit will be complete. When the engine is running at idle rpm (60%) or higher, the switches complete their circuits through the ac generator load limit switch, and the valve opens. Since the vortex destroyer circuit is not completed until the engine reaches idle speed, total bleed air is available for starter operation.

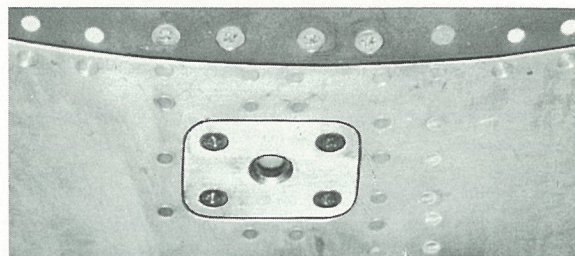
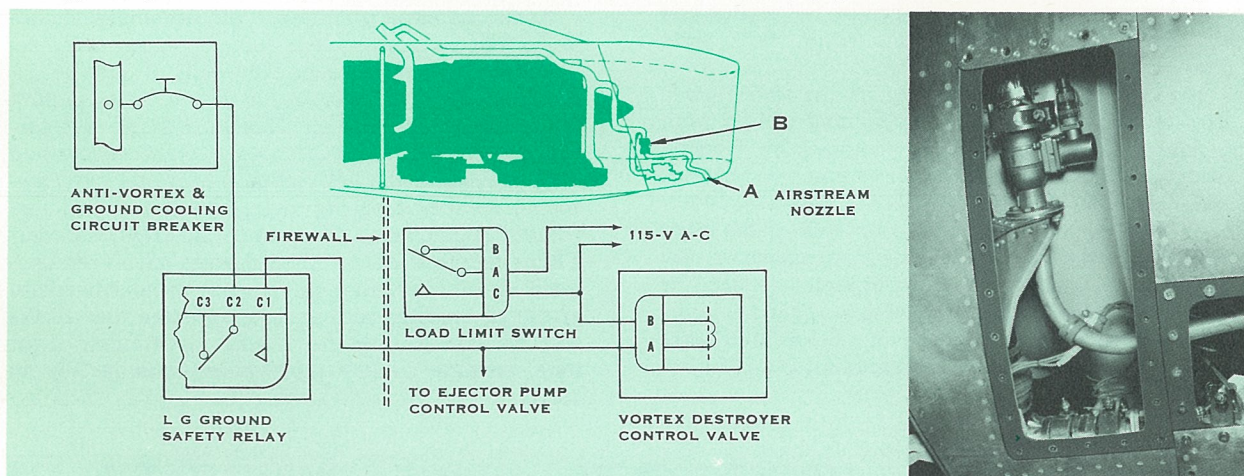
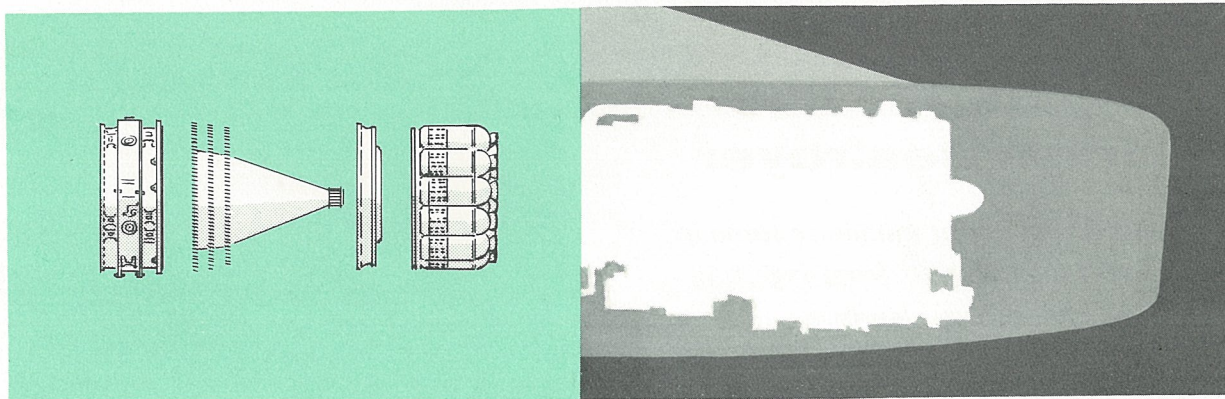


Diagram of vortex destroyer system. Photo above — airstream nozzle (A); photo at right — control valve (B).





Sectionalized Overhaul CJ805-3 Engines

"Sectionalized overhaul," a goal for jet engine maintenance for years, is becoming a reality for the first time, in procedures approved for the Convair 880 power plants—the General Electric CJ805-3 engines.

It has long been recognized that the parts in a jet engine "hot section"—the combustion and turbine areas aft of the compressor rear frame firewall—are more subject to wear and deterioration than are those of the compressor section forward of the firewall. This difference was taken into account officially, for the first time, when the Federal Aviation Agency, in December 1959, approved a schedule of 900 hours between overhaul for the CJ805-3 hot section, and 1600 hours for the cold section.

Design of the CJ805-3 engine lends itself particularly to sectional overhaul. When the exhaust package—thrust reverser and sound suppressor—is removed, the single turbine shaft can be uncoupled from the compressor rotor by use of a long extension wrench. Removal of the ring of flange bolts between combustion and turbine sections allows the turbine section to slide free. The combustion section can then be removed by taking out another ring of bolts. If necessary, it is possible to replace the entire hot section and put the engine back into service within six to eight hours.

The primary gain is economy for the airline operator. It costs more to overhaul the cold section, both in labor and in parts. Data compiled by General Electric, based on several thousand hours of test runs and flight time, showed that CJ805-3 hot section overhaul requires, on the average, only 30% of the labor and 40% of the parts cost. If the more expensive part of the job—overhaul of the cold section—need be done only half as often, the saving is apparent. Using the accepted 1000-hour TBO (time before overhaul) as a norm, labor costs will be approximately 22% less and parts cost will be 9% less.

These percentages are based on airline experience, which indicate that parts consumption costs vary directly with time before overhaul. Costs for both hot and cold section parts increase 5% for each 100-hour extension above 1000 hours. Hot parts costs decrease 5% for each 100-hour reduction in TBO below 1000 hours; cold parts costs decrease less—5% for each 200-hour reduction below 1000 hours.

The original 1600/900-hour TBO is being attained through sampling steps, a procedure standard for reciprocating and jet engines. There are four steps, involving a total of 29 engine overhauls apportioned between the first two "880" fleets. During the sampling period, special hot section inspections will be made, beginning at 400 hours flight time. These are teardown inspections of combustion liners, transition liners, first-stage nozzles, and second- and third-stage turbine shrouds. The inspections will be discontinued at the end of the sampling period, if the data acquired show they are not necessary. Sampling steps are as follows:

Step No.	No. of Engines	Hot Section Inspection	Hot Section TBO	Cold Section TBO
1	6	400±50 hrs	800 hrs	800 hrs
2	7	500±50 hrs	800 hrs	1000 hrs
3	8	600±50 hrs	800 hrs	1200 hrs
4	8	700±50 hrs	800 hrs	1400 hrs

At the conclusion of Step 4, all remaining engines in the fleet can move to the 1600/900-hour schedule.

Requests for subsequent extensions of TBO are at the discretion of the operator. In support of the request for sectionalized overhaul, General Electric was able to show that none of its 1000-hour flight engines had discrepancies in the hot section that would have prevented them from going at least another 300 hours without maintenance. Also, since the 1600/900-hour TBO was approved, CJ805-3 engines have been operated up to 2000 hours in test runs without overhaul of the compressor section. It is expected that TBO's will be extended as the "880's" accumulate flight time, probably to 2000/1000 hours by some time in 1961.

VOLUME XII

NUMBER 3

JULY 1960

Convair Traveler



In this Issue: Sealants, Cements, and Coatings—880/600

VOLUME XII NUMBER 3 JULY 1960

Convair Traveler



In this Issue: Sealants, Cements, and Coatings—880/600

Coming over the fence at Lindbergh Field, San Diego, "880" No. 1 returns home. Ship No. 1 is currently being modified to the 880-M configuration which will feature wing leading edge slats, power boost rudder, more powerful CJ805-3B jet engines.

Convair Traveler

VOLUME XII NUMBER 3 JULY 1960

MANAGER, CUSTOMER SERVICE — J. J. ALKAZIN
CHIEF, TRANSPORT SERVICE — L. J. BORDELON
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AND COATINGS
880/600
Sam Urshan

BACK COVER

VORTEX GENERATORS
CONVAIR 880
Sam Urshan

A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

Sealants, Cements, and Coatings

Convair 880/600

The advanced design of the Convair 880/600 calls for the use of many recently developed chemicals and applications in sealing, cementing, and coating. From the plastic radome on the nose to the finish coat of paint on the tail cone assembly, chemistry plays an important role in the jet airliners. As requirements emerge with new designs, improved materials and processes are developed to keep pace with the advancing art.

In general terms, sealants fill a space or bridge a gap to create continuity between surfaces; cements compel surfaces to adhere to each other; and coatings form a protective or decorative covering over a surface. In some cases, a sealant, cement, or coating will serve more than one function at the same time.

Cabin pressure sealing and weathertight sealing utilize two general purpose sealing compounds—EC-1291 and EC-1293, manufactured by Minnesota Mining and Manufacturing Company. EC-1291 is used in faying surface (lap joint) applications prior to riveting, and is usually applied by brush. EC-1293 is used in fillet (edge, bead) sealing after assembly, and can be spread on by spatula or by pressure gun. Both sealants are supplied in two parts — a base material and an accelerator which must be mixed together before use. They have a work life of four hours and can be cured at room temperature or at elevated temperatures.

Sealants EC-1291 and EC-1293 may also be used to repair leaks in integral fuel tanks. In this application, EC-1291 or EC-1293 is coated after use with another 3M product — EC-776R, a single-component nitrile derivative — to prevent the sulfur mercaptan in fuel from attacking the Thiokol in the sealants. EC-776R is colored by red analine dye to aid in observing its application and to insure complete coverage over the sealant. Sealants EC-1291 and EC-1293, which are Thiokol-based, are used in non-Skydrol areas.

EC-1663 and EC-1667 are used as sealants in areas exposed to spillage of fuels, oils, and Skydrol hydraulic fluid. They also are two-part compounds which must be mixed with a catalyst before application. EC-1663, applied with brush or by injection, is used in faying surface sealing; EC-1667, spread with spatula or with pressure gun, is used in fillet sealing. These sealants, which have a silicone base, must be applied over an EC-1662 primer to insure satisfactory adhesion to the metals and materials they seal.

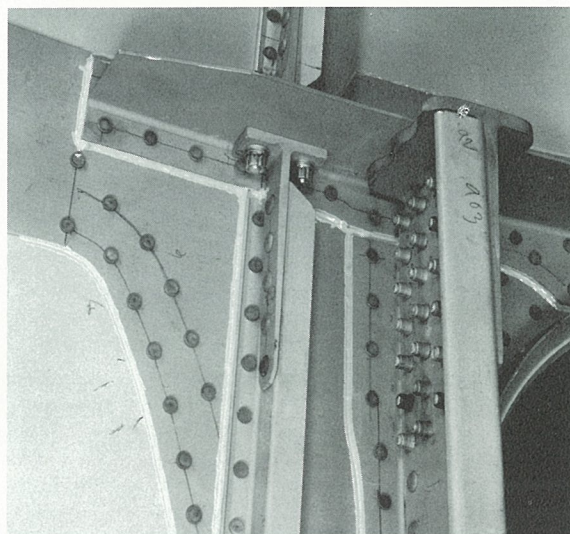
Aerodynamic smoothing compound is used to fair in the edges of the wing splice plates, and may be used in service to smooth out non-structural damages to exterior surfaces.

On painted areas, 3M Company EC-1653 is used; on unpainted Skydrol areas, EC-1927 is applied. These two sealants are two-part compounds and require catalysts to prepare them for use. Putty-like in consistency, they may be spread on by spatula or by pressure gun. EC-1927 must be applied over EC-1662 primer to insure proper adhesion.

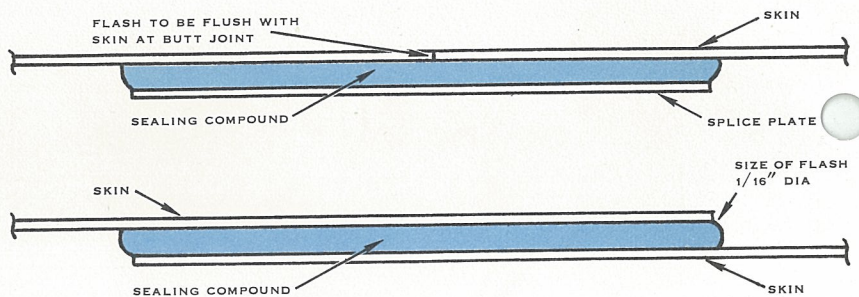
Relatively new, yet finding widespread use as a general purpose sealant, is QC-2-0078, manufactured by Dow-Corning. This single-component silicone-base sealant, requires no catalyst or primer before use and is readily applicable to most sealing jobs including those in Skydrol areas. It is not, however, applicable in fuel areas. QC-2-0078 may be applied by tube (in which it comes) or by pressure gun.

Permagum 576-1, manufactured by Hubbard Corporation, is used to seal the aircraft floor against moisture, in areas where liquids might be spilled, and to prevent these liquids from entering into and corroding the airframe structure underneath the floors. The putty-like Permagum is applied at the butt joints of the honeycomb floor panels beneath the rug in the entrance, buffet, and lavatory areas.

The use of adhesive cements and compounds for fastening purposes, particularly in the fabrication of interior trim and furnishings, has contributed much to the advanced design of the Convair 880/600. Bonding similar and dissimilar materials with adhesive cements and compounds rather than by the use of metal fasteners has resulted in substantial savings in aircraft weight and complexity.



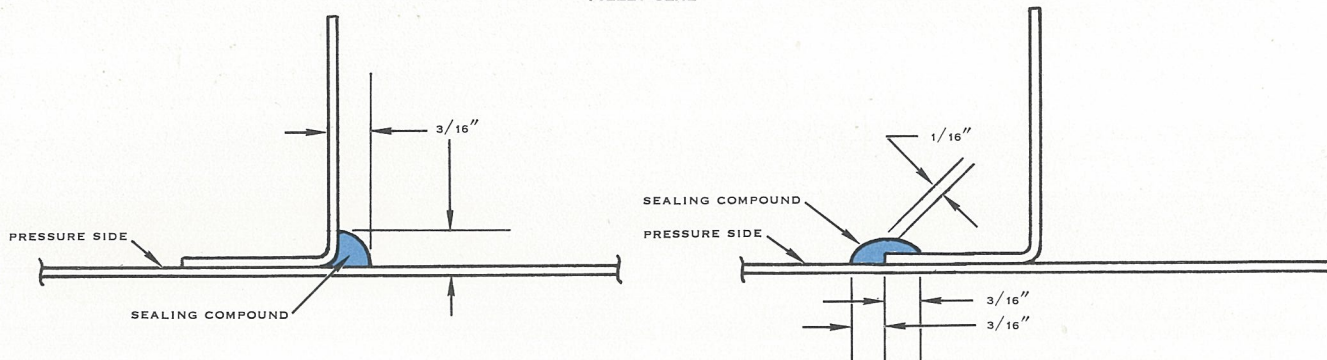
Cargo door frame tie-in to skin panel shows fillet sealing of longerons, frames, doubler.



The following tables list the recommended sealants, cements, and coatings used during manufacture and for maintenance and repair of the various installations in the airplane.

WING				
SPECIFICATION NO. & MANUFACTURER	TYPE	USAGE	MIXING PROPORTIONS	
			BASE	ACCEL.
EC-1291 Minnesota Mining & Mfg.	Thiokol Sealant	Wing fuel tank repair. Relief hole plugs. Bonding vortex generators.	100 EC-1291	12 EC-1292
EC-776R Minnesota Mining & Mfg.	Nitrile Coating	Fuel tank repair coating. Prevents sulphur mercaptan in fuel from attacking Thiokol sealant.	3 grams red aniline dye to 1 gal. EC-776	
EC-1293 Minnesota Mining & Mfg.	Thiokol Sealant	Wing fuel tank repair. Relief hole plugs. Bonding vortex generators.	100 EC-1293	12 EC-1366
EC-1653 Minnesota Mining & Mfg.	Thiokol Sealant	Aerodynamic sealing of exterior butt joints & fairing in all except unpainted Skydrol areas.	100 EC-1653B	8 EC-1653A
EC-1927 Minnesota Mining & Mfg.	Silicone Sealant	Aerodynamic sealing of exterior butt joints and fairing on unpainted Skydrol areas.	100 EC-1927B	20 EC-1927A
QC-2-0078 Dow-Corning	Silicone Sealant	Aerodynamic sealing of exterior butt joints and fairing on unpainted Skydrol areas.	Single component	
Super Koropon 765 DeSoto Chem. Co.	Epoxy Primer	Corrosion inhibitor for areas subject to Skydrol contact.	1 Base	1 Converter
A-423 Gray Andrew Brown Co.	Epoxy Top Coat	Seals Epoxy primer for aircraft exterior. Color selection according to customer. Abrasion resistant.	1 Base	1 Converter
A-423 White Andrew Brown Co.	Epoxy Top Coat	Seals Epoxy primer for landing gear wells. Abrasion resistant.	1 Base	1 Converter
A-423 Moly Black Andrew Brown Co.	Epoxy Top Coat	Chafe-preventive coating on landing gear door edges.	1 Base	1 Converter
MIL-C-8514	Wash Primer	Optimum paint adhesion of zinc chromate primer on exterior aluminum alloy castings in non-Skydrol areas, wing tip trailing edge, anti-shock body tips.	4 Resin	1 Acid
MIL-P-8585	Zinc Chromate Primer	Corrosion inhibitor on exterior aluminum alloy castings in non-Skydrol areas. Tip trailing edge & anti-shock body tips.	1 Primer	2 1/2 Toluene
MIL-L-7178	Nitro Cellulose Lacquer	Gloss gray top coat over primer on aluminum alloy castings in non-Skydrol areas. Wing tip trailing edge & anti-shock body tips.	Single component	
EC-1662 Minnesota Mining & Mfg.	Silicone Primer	Primer for EC-1927	Single component	

FILLET SEAL



APPLICATION	FLOW	TEMP. LIMIT ° F	WORK LIFE	CURE TIME HOURS	° F	RECOMMENDED SHELF LIFE	COLOR
Brush, injection	high	275	4 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	tan
Brush over EC-1291, EC-1293	liquid	-	-	24 before operation	Room	3 mo. Room Temp.	red
Spread by pressure gun, spatula	medium	275	4 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	light tan
Spread by spatula, pressure gun	low	275	4-6 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	gray
Spread by spatula, pressure gun over EC-1662 primer	low	550-600 intermittent	1-2 hr.	24	Room	6 mo. 40° F - 50° F	gray
Spread by tube, pressure gun	low	550-600 intermittent	-	24	Room	3 mo. Room Temp.	gray
Spray 0.0007"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	light yellow
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	gray
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	white
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	black
Spray 0.0003"	liquid	350	4 hr.	1/2	Room	1 yr. Room Temp.	tan
Spray 0.0004"	liquid	350	-	1/2 dry 24 cure	Room Room	1 yr. Room Temp.	yellow
Spray 0.00075"	liquid	285	-	48 before operation	Room	1 yr. Room Temp.	gray
Brush	liquid	-	-	1	Room	6 mo. 40° F - 50° F	red

FUSELAGE

SPECIFICATION NO. & MANUFACTURER	TYPE	USAGE	MIXING PROPORTIONS	
			BASE	ACCEL.
EC-1291 Minnesota Mining & Mfg.	Thiokol Sealant	Cabin pressure sealing in non-Skydrol areas. Faying surfaces. Relief hole plugs.	100 EC-1291	12 EC-1292
EC-1293 Minnesota Mining & Mfg.	Thiokol Sealant	Cabin pressure fillet sealing in non-Skydrol areas. Relief hole plugs.	100 EC-1293	12 EC-1366
EC-1293 (Quick Cure) Minnesota Mining & Mfg.	Thiokol Sealant	Used in place of EC-1293 when a shorter cure time is required.	100 EC-1293	12 EC-1366
EC-1663 Minnesota Mining & Mfg.	Silicone Sealant	Faying surface sealing in Skydrol areas. Relief hole plugs.	100 EC-1663B	10 EC-1663A
EC-1667 Minnesota Mining & Mfg.	Silicone Sealant	Fillet sealing in Skydrol areas. Relief hole plugs. Gap sealing pilots' windshields.	100 EC-1667B	10 EC-1667A
EC-1662 Minnesota Mining & Mfg.	Silicone Primer	Primer for EC-1663, EC-1667, EC-1927.	Single component	
EC-1653 Minnesota Mining & Mfg.	Thiokol Sealant	Aerodynamic sealing of exterior butt joints & fairing in all except unpainted Skydrol areas.	100 EC-1653B	8 EC-1653A
EC-1927 Minnesota Mining & Mfg.	Silicone Sealant	Aerodynamic sealing of exterior butt joints & fairing on unpainted Skydrol areas.	100 EC-1927B	20 EC-1927A
QC-2-0078 Dow-Corning	Silicone Sealant	Aerodynamic sealing of exterior butt joints and fairing on unpainted Skydrol areas.	Single component	
MIL-C-8514	Wash Primer	Optimum paint adhesion of zinc chromate primer on magnesium alloys, aluminum skins, fuselage skin, & inner surfaces.	4 Resin	1 Acid
MIL-P-8585	Zinc Chromate Primer	Corrosion inhibitor for aircraft interior — magnesium, aluminum, cadmium plated steel, in non-fuel & non-Skydrol areas.	1 Primer	2 1/2 Toluene
MIL-L-7178	Nitro Cellulose Lacquer	Top coat over primer for gloss gray appearance of exterior surfaces in non-fuel & non-Skydrol areas.	Single component	
Super Koropon 765 DeSoto Chem. Co.	Epoxy Primer	Corrosion inhibitor for aircraft interior in Skydrol areas.	1 Base	1 Converter
A-423 Gray Andrew Brown Co.	Epoxy Top Coat	Seals Epoxy primer for aircraft exterior. Color selection according to customer. Abrasion resistant.	1 Base	1 Converter
A-423 White Andrew Brown Co.	Epoxy Top Coat	Seals Epoxy primer & provides abrasion- resistant top coat in landing gear wells.	1 Base	1 Converter
A-423 Moly Black Andrew Brown Co.	Epoxy Top Coat	Chafe-preventive coating on passenger & service door tracks.	1 Base	1 Converter

APPLICATION	FLOW	TEMP. LIMIT ° F	WORK LIFE	CURE TIME HOURS	° F	RECOMMENDED SHELF LIFE	COLOR
Brush, injection	high	275	4 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	tan
Spread by pressure gun, spatula	medium	275	4 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	light tan
Spread by pressure gun, or spatula	medium	275	5 min.	1 hr.	Room	3 mo.	tan
Brush, injection over EC-1662 primer	high	550-600 intermittent	2-4 hr.	24	Room	6 mo. 40° F - 50° F	red
Spread by pressure gun, spatula over EC-1662 primer	low	550-600 intermittent	2-4 hr.	24	Room	6 mo. 40° F - 50° F	red
Brush	liquid	-	-	1	Room	6 mo. 40° F - 50° F	red
Spread by spatula, pressure gun	low	275	4-6 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	gray
Spread by spatula, pressure gun over EC-1662 primer	low	550-600 intermittent	1-2 hr.	24	Room	6 mo. 40° F - 50° F	gray
Spread by tube, pressure gun	low	550-600 intermittent	-	24	Room	3 mo. Room Temp.	gray
Spray 0.0003"	liquid	350	4 hr.	1/2	Room	1 yr. Room Temp.	tan
Spray 0.0004"	liquid	350	-	1/2 dry 24 cure	Room	1 yr. Room Temp.	yellow
Spray 0.00075"	liquid	285	-	48 before operation	Room	1 yr. Room Temp.	gray
Spray 0.0007"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	light yellow
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	gray
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	white
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	black

ELECTRICAL & AVIONICS

SPECIFICATION NO. & MANUFACTURER	TYPE	USAGE	MIXING PROPORTIONS	
			BASE	ACCEL.
Coast Pro-Seal 777 Coast Pro-Seal Mfg. Co.	Polyurethane Sealant	Potting compound for electrical connectors.	100 Part A then mix 1 Part C to mixture of Parts A & B	7.5 Part B
EPON 828 Shell	Epoxy Sealant	Potting compound for electrical connectors.	100 EPON 828	15 HN 951
EC-1300 Minnesota Mining & Mfg.	Rubber Cement	Bonding erosion boot to plastic radome.	Single component	
467-2 Finch Paint & Chem. Co.	Epoxy Putty	Filler putty for smoothing minor surface defects on radome surface before applying anti-static coating.	100 Base	2.5 Catalyst
453-1-1 Finch Paint & Chem. Co.	Epoxy Top Coat - Blk.	Radome & dorsal antenna anti-static coating.	100 Base	2.65 Catalyst
EC-1293 Minnesota Mining & Mfg.	Thiokol Sealant	Fillet sealing of antenna base & fuselage skin in non-Skydrol areas.	100 EC-1293	12 EC-1366
EC-1663 Minnesota Mining & Mfg.	Silicone Sealant	Faying surface sealing of antenna base to fuselage in Skydrol areas.	100 EC-1663B	10 EC-1663A
EC-1662 Minnesota Mining & Mfg.	Silicone Primer	Primer for EC-1663.	Single component	

EMPENNAGE

SPECIFICATION NO. & MANUFACTURER	TYPE	USAGE	MIXING PROPORTIONS	
			BASE	ACCEL.
EC-1291 Minnesota Mining & Mfg.	Thiokol Sealant	Pressure sealing faying surfaces of rudder feel system; bonding vortex generators.	100 EC-1291	12 EC-1292
EC-1293 Minnesota Mining & Mfg.	Thiokol Sealant	Bonding vortex generators.	100 EC-1293	12 EC-1366
EC-1653 Minnesota Mining & Mfg.	Thiokol Sealant	Aerodynamic smoothness of exterior surfaces — minor damages.	100 EC-1653B	8 EC-1653A
MIL-C-8514	Wash Primer	Optimum paint adhesion of zinc chromate primer on magnesium alloys, aluminum skins, & inner surfaces.	4 Resin	1 Acid
MIL-P-8585	Zinc Chromate Primer	Corrosion inhibitor for aircraft interior; magnesium, aluminum, cadmium plated steel; for use in non-Skydrol areas.	1 Primer	2 1/2 Toluene
MIL-L-7178	Nitro Cellulose Lacquer	Top coat over primer for gloss gray appearance of exterior surfaces in non-fuel & non-Skydrol areas.	Single component	
Super Koropon 765 DeSoto Chem. Co.	Epoxy Primer	Corrosion inhibitor for aircraft interior in Skydrol areas.	1 Base	1 Converter
A-423 White Andrew Brown Co.	Epoxy Top Coat	Seals Epoxy primer for aircraft exterior. Color determined by customer requirements. Abrasion-resistant.	1 Base	1 Converter

APPLICATION	FLOW	TEMP. LIMIT ° F	WORK LIFE	CURE TIME HOURS	° F	RECOMMENDED SHELF LIFE	COLOR
Extruded into mold after applying Coast Pro-Seal Primer	high	300-350 intermittent	90 min. @75° F	48 5 1/2	77 140 220	3 mo. 40° F - 50° F	light tan
Poured into mold	high	250-300 intermittent		12-24	Room	6 mo. 32° F - 80° F	light tan
Brush	high	-	-	immed- iate	Room	60 - 80 days Room Temp.	yellow
Plastic scraper	low	400	24 hr.	15 min. 24	250 Room	1 yr. Room Temp.	white
Spray 0.001"	liquid	400	24 hr.	25 min. (approx.)	250	1 yr. Room Temp.	black
Spread by spatula, pressure gun	medium	275	4 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	light tan
Brush, injection over EC-1662 primer	high	550	2-4 hr.	24	Room	6 mo. 40° F - 50° F	red
Brush	liquid	-	-	1	Room	6 mo. 40° F - 50° F	red

APPLICATION	FLOW	TEMP. LIMIT ° F	WORK LIFE	CURE TIME HOURS	° F	RECOMMENDED SHELF LIFE	COLOR
Brush, injection	high	275	4 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	tan
Spread by pressure gun, spatula	medium	275	4 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	light tan
Spread by spatula, pressure gun	low	275	4-6 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	gray
Spray 0.0003"	liquid	350	4 hr.	1/2	Room	1 yr. Room Temp.	tan
Spray 0.0004"	liquid	350	-	1/2 dry 24 cure	Room Room	1 yr. Room Temp.	yellow
Spray 0.00075"	liquid	285	-	48 before operation	Room	1 yr. Room Temp.	gray
Spray 0.0007"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	light yellow
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	white

INTERIOR EQUIPMENT

SPECIFICATION NO. & MANUFACTURER	TYPE	USAGE	MIXING PROPORTIONS	
			BASE	ACCEL.
Permagum 576-1 Hubbard Corp.	Sealant	Moisture & liquid sealing between entrance area carpet and floor and around buffet and lavatory areas.	Single component	
EC-2063 Minnesota Mining & Mfg.	Neoprene Latex Cement	Bonding fabrics to interior trim panels.	Single component	
Polyurethane 1214 Applied Plastics Corp.	Polyurethane Cement	Bonding perforated vinyl fabric (Boltaron) to foam core or open weave fabrics on acoustical panels.	Single component	
EC-870 Minnesota Mining & Mfg.	Neoprene Cement	Bonding rubber and Neoprene to themselves, to each other, and to metal.	Single component	
EC-847 Minnesota Mining & Mfg.	Nitrile Cement	Bonding vinyl and rubber materials to steel, aluminum, and wood.	Single component	
Stabond T-161 American Latex Products	Rubber Cement	Bonding flexible Polyurethane foam to itself and to other materials.	Single component	
Narmco 3135	Epoxy Adhesive	General purpose, extremely high chemical-resistant bond for fiberglass components to self and to metal.	50 3135B	50 3135A
A-117 Mystik Products	Silicone Base Cement	Bonding Teflon and other plastics to metal (pressure sensitive).	Single component	

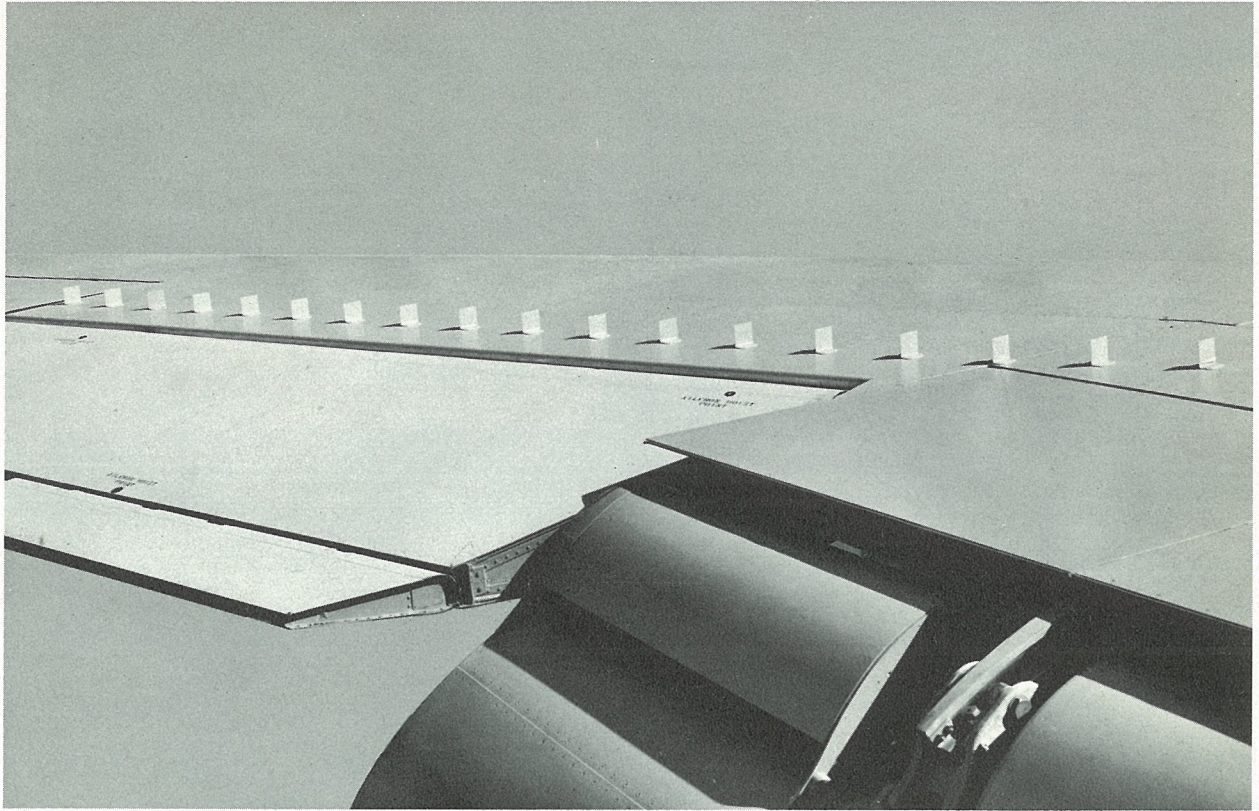
24 10

PODS & PYLONS

SPECIFICATION NO. & MANUFACTURER	TYPE	USAGE	MIXING PROPORTIONS	
			BASE	ACCEL.
EC-1663 Minnesota Mining & Mfg.	Silicone Sealant	Faying surface sealing on pods and pylons in Skydrol areas.	100 EC-1663B	10 EC-1663A
EC-1667 Minnesota Mining & Mfg.	Silicone Sealant	Fillet sealing on pods and pylons in Skydrol areas.	100 EC-1667B	10 EC-1667A
EC-1662 Minnesota Mining & Mfg.	Silicone Primer	Primer for EC-1663, EC-1667, EC-1927.	Single component	
EC-1653 Minnesota Mining & Mfg.	Thiokol Sealant	Aerodynamic sealing of exterior butt joints and fairing in all except unpainted Skydrol areas.	100 EC-1653B	8 EC-1653A
EC-1927 Minnesota Mining & Mfg.	Silicone Sealant	Aerodynamic sealing of exterior butt joints and fairing on unpainted Skydrol areas.	100 EC-1927B	20 EC-1927A
QC-2-0078 Dow-Corning	Silicone Sealant	Aerodynamic sealing of exterior butt joints and fairing on unpainted Skydrol areas.	Single Component	
Super Koropon 765 DeSoto Chem. Co.	Epoxy Primer	Corrosion inhibitor for pods and pylons in Skydrol areas.	1 Base	1 Converter
A-423 Andrew Brown Co.	Epoxy Top Coat	Seals Epoxy primer for aircraft exterior. Color according to customer requirements. Abrasion-resistant.	1 Base	1 Converter

APPLICATION	FLOW	TEMP. LIMIT ° F	WORK LIFE	CURE TIME HOURS	° F	RECOMMENDED SHELF LIFE	COLOR
Spread by spatula	low	-	-	-	-	-	white
Water-dispersed spray, brush	liquid	-	-	24 before operation	Room	4 mo. 60° F - 80° F (no freeze)	cream wet amber dry
Spray, brush	liquid	-	-	24 before operation	Room	3 mo. 70° F 6-12 mo. 40° F	pale clear yellow
Spray, brush	liquid	-	-	24 before operation	Room	6 mo. 60° F - 80° F	light tan
Spray, brush	liquid	-	-	24 before operation	Room	6 mo. 60° F - 80° F	brown
Spray, brush	liquid	-	-	24 before operation	Room	6 mo. 60° F - 80° F	clear
Brush	low	250	1 hr.	24 1	Room 200	6 mo. 50° F - 90° F	yellow cured- light amber
Brush	medium	-320 to 500	-	1	Room	6 mo. 40° F - 50° F	white

APPLICATION	FLOW	TEMP. LIMIT ° F	WORK LIFE	CURE TIME HOURS	° F	RECOMMENDED SHELF LIFE	COLOR
Brush, injection over EC-1662 primer	high	550-600 intermittent	2-4 hr.	24	Room	6 mo. 40° F - 50° F	red
Spread by pressure gun, spat- ula over EC-1662 primer	low	550-600 intermittent	2-4 hr.	24	Room	6 mo. 40° F - 50° F	red
Brush	liquid	-	-	1	Room	6 mo. 40° F - 50° F	red
Spread by spatula, pressure gun	low	275	4-6 hr.	4 24	110-130 Room	3 mo. 40° F - 50° F	gray
Spread by spatula, pressure gun over EC-1662 primer	low	550-600 intermittent	1-2 hr.	24	Room	3 mo. 40° F - 50° F	gray
Spread by tube, pressure gun	low	550-600 intermittent	-	24	Room	3 mo. Room Temp.	gray
Spray 0.0007"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	light yellow
Spray 0.001"	liquid	400	8 hr.	48 before operation	Room	1 yr. Room Temp.	white



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Vortex Generators Convair 880

The small airfoil sections lined up along the wings and the vertical stabilizer on the Convair 880 are not foot-holds for some agile mechanic, but are vortex generators whose function is to increase the effectiveness of the aileron trim tabs and the rudder, throughout the higher speed ranges.

Installed upstream of the ailerons and rudder, the vortex generators are positioned perpendicular to the flight surfaces at a small angle to the airstream, and act in the manner of miniature wings in forming vortices that energize the boundary layer over the control surfaces. As the vortices swirl into the boundary layer, which would otherwise be separated from the trailing edges of the surfaces, the boundary layer mixes with the airstream and allows the airstream to contact the control surfaces.

The vortex generators are injection-molded of Lexan plastic, developed by the Chemical and Metallurgical Division of the General Electric Company. They are bonded to the wings and vertical stabilizer by EC-1291 or EC-1293, a sealant-adhesive manufactured by the Minnesota Mining and Manufacturing Company.

Prior to installation, the vortex generator is lightly sand-blasted or hand-sanded to remove its glossy surface and to allow epoxy paint to adhere to the plastic. The epoxy top coat protects the plastic against attack by mild solvents and cleaning agents used in servicing the aircraft.

A total of 98 vortex generators are used on the Convair 880 — 18 on each wing, and 31 on each side of the vertical stabilizer.

CONVAIR SAN DIEGO

CONVAIR DIVISION

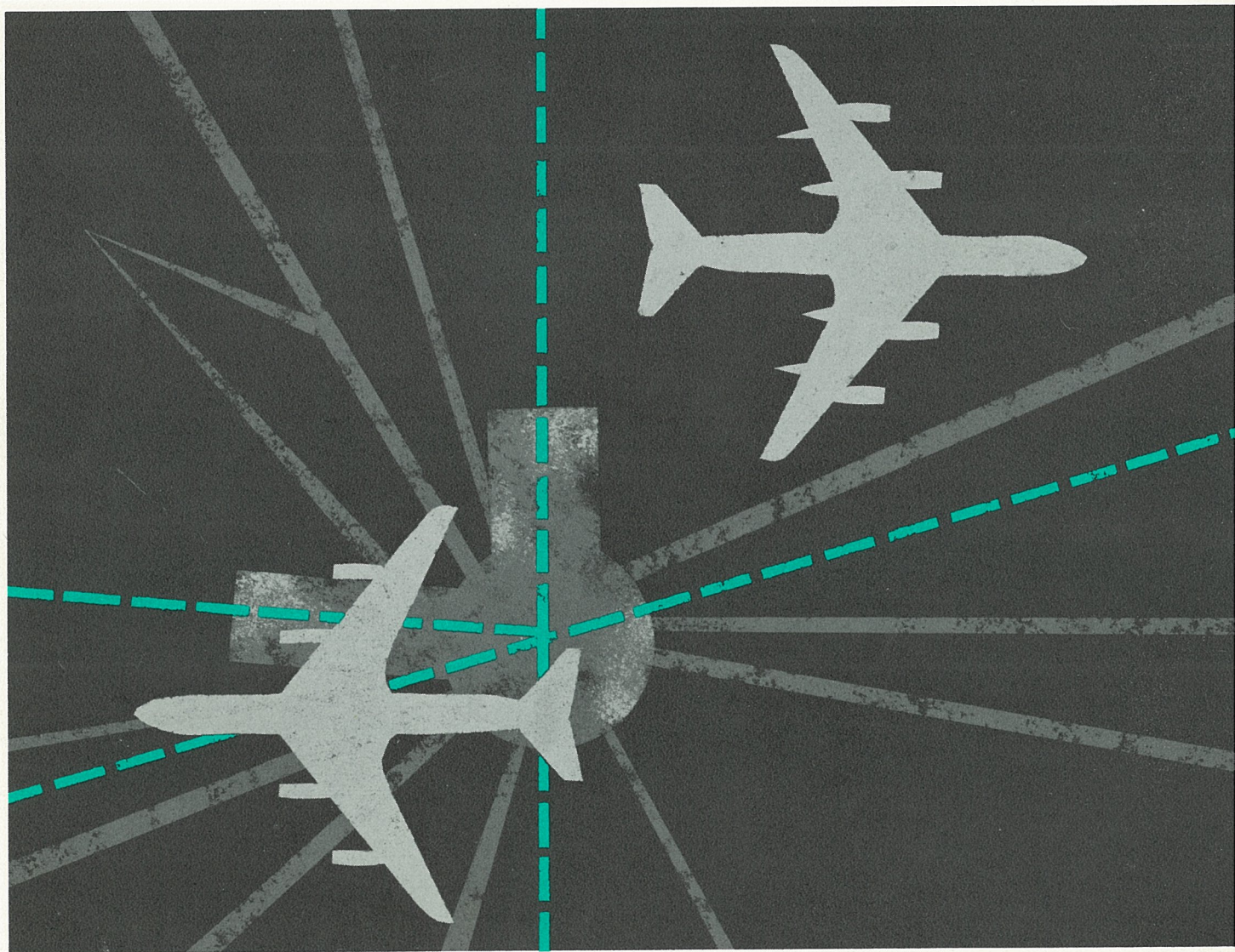
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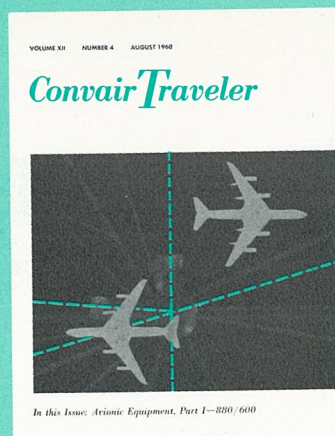
NUMBER 4

AUGUST 1960

Convair **Traveler**



In this Issue: Avionic Equipment, Part I—880/600



OUR COVER

Today's navigation maps, by which the Convair 880 and 600 find their way, would puzzle the old cartographers as much as would a flyby of the aircraft themselves. Artist for this issue is Willis Goldsmith.

Convair Traveler

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Avionic Equipment—Convair 880/600

Part I: Radio Navigation & Communications, Airplane Intercommunication System

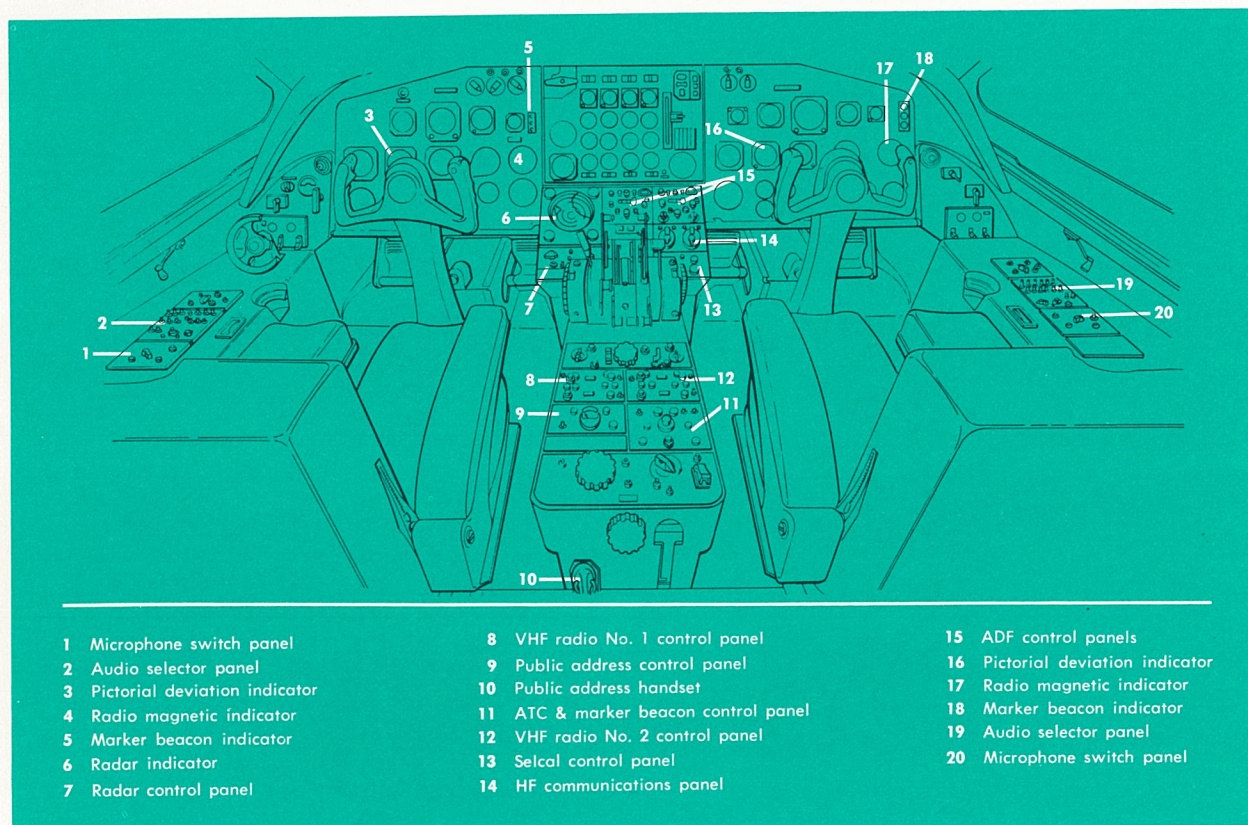
The typical Convair 880/600 jet airliners will begin route operations with approximately eleven radio receivers and three voice transmitters. Each will also have at least one complete weather radar; one receiver-transmitter, to answer automatically-coded queries from the ground; one transmitter-receiver, to interrogate a ground transponder and interpret the reply in miles of distance; and a full public-address and interphone system. Besides these, certain aircraft will have a calling device, to "ring up" the crew from the ground; a long-range navigation receiver to pinpoint positions in mid-ocean; more radar sets to measure ground speed, drift angle, altitude, or to warn of terrain obstacles; a tape reproducer to play music to the passengers; and more spare receivers and transmitters, in case the others fail. If these latter are not in the airplane, the space is there for them, sometimes with antennas, wiring, and connections, so that the units may be merely set in place and hooked up.

This impressive roster of equipment is not, of course, a literal necessity for flight. As far as the airplane is concerned, any competent pilot could fly an

"880" or "600" across the continent in halfway decent weather without ever turning on a radio. But that is just not done — not in a commercial transport in 1960. With this equipment in use, the pilot has at his command not only a wide assortment of radio azimuth-finding and piloting aids, but the backing of vast airways systems—national and worldwide—designed to help him find his way and to land safely, at any hour of day or night, in almost any kind of weather.

The basic units that are installed in all "880" and "600" aircraft make available all the ground facilities of the Federal airways. It may occur to some to wonder why basic equipment must include, for example, a dozen receivers (although some are duplicates) to fly radio ranges. The answer lies in the patterns of the navigational networks that have grown up over the past thirty years, changing rapidly since World War II and still changing today.

At the risk of boring some readers already familiar with the patterns, this description will review them briefly in considering the Convair jet airliner navigation and communications electronic equipment.



Flight compartment (typical) showing locations of radio and radar equipment.

RADIO NAVIGATION EQUIPMENT

ADF, VHF, Glide Slope, Marker Beacon, DMET, LORAN

Five basic types of receivers in the airplane will be used solely for navigation, to utilize the airway navigation facilities. These are extensive. On standard aeronautical charts, even skeletal radio data crowds the map areas around major airports. Separate radio guides and charts are a necessity. Airports may utilize up to 20 or more frequency channels, from low to ultra-high. As of last July, more than 60 civil airports had radar-controlled GCA (ground-controlled approach) systems; twice as many had ILS (instrument landing system) facilities.

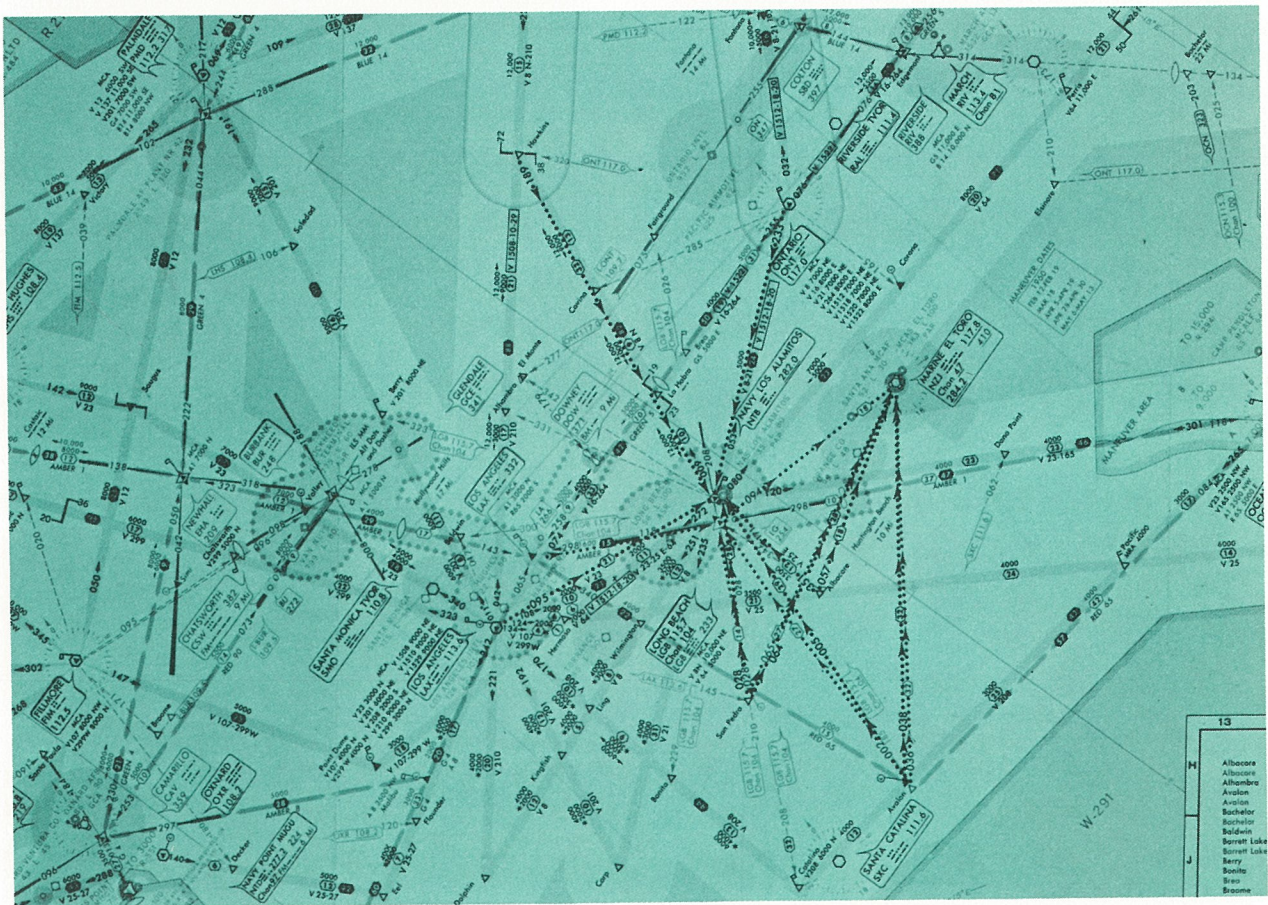
Airways have been marked since the early 1930's with low-frequency directional radio beams. This network, though still existing today, is all but supplanted for commercial use by a very-high-frequency (VHF) omnirange radio network, and will soon be discontinued altogether.

The pilot of an "880" or "600" airplane can still fly by the low-frequency four-course A-N quadrant signals familiar to a generation of flyers; or, more probably, by using these signals to operate his radio compass. This system is known as automatic direction finding (ADF) and, under optimum conditions, may be operable over a range of several hundred miles. In

its earliest form, dating back to World War I, the receiver had a loop antenna, linked to an azimuth card; the signal would come in strongest when the plane of the loop pointed toward the broadcast station, weakest when the loop was at right angles to the station direction.

The contemporary ADF receiver still uses such a loop. On the "880," it is mounted in the bottom of the fuselage; on the "600," it is mounted in the top. By a switch on the flight compartment control panel, the operator can rotate the antenna to an aural null. The usual mode of operation, however, utilizes a second non-directional sense antenna on top of the fuselage, comparing the non-directional signal with the directional one from the loop so as to position the loop automatically. Bearing of the broadcast station is transmitted by servos to radio magnetic indicators (RMI's) on the pilot's panels. Each RMI has a compass-controlled azimuth card with two pointer needles. There are two ADF receivers; each may control one needle. Two stations can be turned in at once, establishing two lines of position by the RMI needles.

Frequency range of ADF is 90 to 1800 kc. In addition to the airway range stations, this range includes



Excerpt from radio navigation chart of Los Angeles area.

standard AM broadcast bands, often used by pilots in the early days — particularly if the music was good.

ADF radio today has two limitations, one inherent and one arising from recent technological advances. First, low-frequency reception is subject to external static interference; the automatic direction finder on occasion can be merely an inefficient thunderstorm finder. Second, today's airborne equipment has, as far as possible, eliminated vacuum tubes. The silicon diodes used in transformer-rectifier and other electrical equipment are miniature low-frequency broadcasting units. The resultant interference from inside the airplane has, for practical purposes, proved impossible to eliminate completely, and the effective range of ADF has dropped accordingly in the new jet transports. Convair engineering has been able to filter out an unusual amount of the noise, but the consensus is that ADF will probably never be as efficient in new aircraft as it was when vacuum tubes were more common in the electronic equipment.

ADF, however, is of secondary importance to the jet airplane. Most civilian high-speed aircraft, when following major air routes by radio, navigate almost entirely by VHF (very high frequency) radio. The frequencies are from 108 to 117.9 megacycles, where static interference is far less. Reception is limited to line-of-sight distance — at 35,000 feet altitude, 175 to 200 miles. Today, continental United States is well blanketed by omnirange facilities, and aircraft on the principal airways are never outside range of a VHF station.

There are two omnirange systems in current use, VOR (VHF Omnidirectional Range) and ultra-high-frequency TACAN (TACTical Air Navigation), the latter principally military for direction-finding purposes. Both broadcast two signals simultaneously,

one a reference signal and the other variable. The signals are beamed in all directions (hence "omni") but provide a directional signal for the airborne receiver.

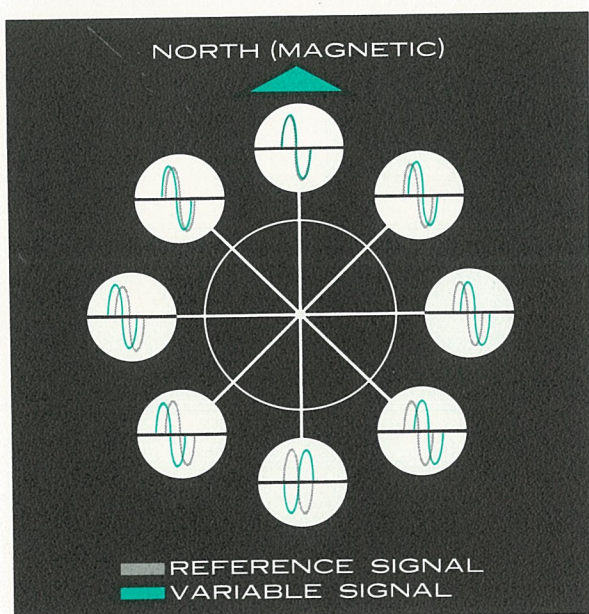
The VOR receiver measures a phase difference between the two radio signals. The reference signal, transmitted by FM on a frequency between 112 and 118 mc, is modulated to 30 cycles per second with a constant phase in all directions; the variable signal, transmitted by AM, is also 30-cycle, and is in phase with the reference signal along the magnetic north beam, but out of phase in other directions, depending on the direction of the receiver from the transmitter. The receiver compares the two phase signals; the difference in phase is interpreted into an instrument reading of the bearing of the transmitter.

There are two VOR receivers on each Convair 880 and 600. Output of the receiver formerly was to an omnibearing indicator (OBI). For instrument purposes, "880" and "600" aircraft, though they may still have an OBI, make principal use of the VOR signal in RMI's and/or deviation indicators on the pilot's panels. There are several types of instrument systems available. In some, the bearing of the VOR station may show on the RMI, with or without simultaneous ADF bearings; or the bearing may show on a compass repeater with a second pair of RMI needles. In all "880" and "600" aircraft, deviation of the airplane from the selected radial of the VOR station will be shown on some indicator — the radial's position and angle relative to airplane heading, whether right or left, and how much right or left. The VHF navigation receiver provides an aural output for station identification and scheduled weather broadcasts.

A number of airports have a short-range low-power terminal omnirange (TVOR) for lining up with the runway during instrument flight letdowns. Most of the country's major airports now have more sophisticated Instrument Landing System facilities.

An ILS transmitter near the runway transmits two highly directional localizer signals side by side, one modulated to 90 cps and the other to 150 cps, on radio frequencies between 108 and 111.9 mc, just below the VOR band. The vertical plane along which the lobes of the two signals overlap is aligned with the runway; the airborne VHF navigation receiver, on ILS frequencies, has circuitry to respond to this pair of signals as in VOR reception, and the deviation indicator will show position and heading of the airplane relative to the localizer beam.

A second element of the ILS system is a glide slope transmitter, which also puts out two overlapping lobes of directional beams, one above the other. The lateral plane of overlap is the glide slope, projected up from the end of the runway at 2.5° to 3° angle. Carrier frequency of the glide slope is between 328.6 and 335.4 mc, in the UHF (ultra-high-frequency) range. Since reception is simultaneous with localizer reception, a separate receiver is required. Tuning the VHF navigation receiver to the localizer frequency automatically tunes the glide slope receiver. Instrumental



VOR 30-CYCLE WAVE PATTERNS

output of the glide slope receiver is to the flight instrument system; relative position of the slope is shown by a horizontal bar, displaced from instrument vertical center by an amount proportional to the airplane vertical distance from the glide slope.

VHF navigation and glide slope receivers have a second important function in flight; the autopilot can be placed under their control. In "880" and "600" aircraft, the autopilot will take the airplane to a VOR radial and follow it to the transmitter, over it, and away from it on a reciprocal heading. In ILS autopilot operation, the airplane will automatically find the center of the localizer beam, follow it to the intersection with the glide slope, automatically lock on the glide slope, and follow it down to the runway end.

A third element of the ILS system requires still another unit, the marker beacon receiver, permanently tuned to 75 mc. Ground radio beacons transmit a 75-mc modulated signal straight up, in cone, fan, or bone-shaped patterns, to mark certain points. An ILS approach lane will have outer and middle markers at 1- to 15-mile distances; as an airplane passes over one, a momentarily strong signal will be received — modulated with 400 cycles over the outer marker and with 1300 cycles over the middle marker — carrying Morse code identification. Marker beacons also mark enroute points on the airways and the cone of silence over low-frequency range stations; these signals are modulated to 3000 cycles. However, enroute markers are being discontinued along with the low-frequency network.

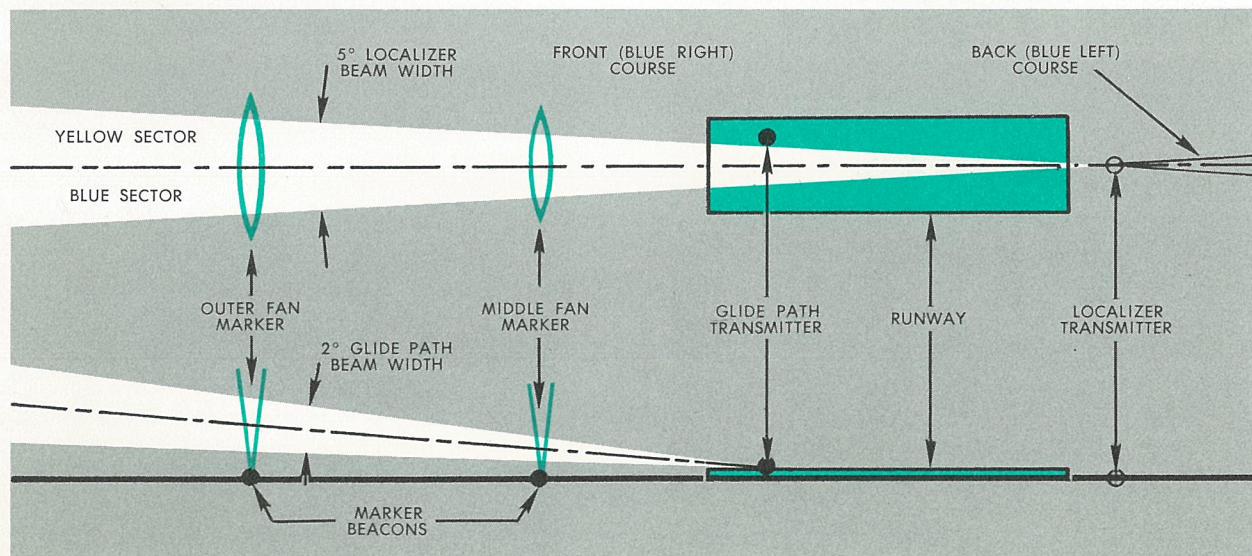
The tones may be heard in the headsets or flight compartment speakers. On some airplanes, colored lamps on the instrument panels illuminate when the signal is received.

The other omnirange system, TACAN, operates similarly to VOR, except that frequency range is between 962 and 1213 mc. TACAN transmitters are frequently found together with VOR, in ground units

identified as VORTAC stations. Since VOR supplies bearing information, this portion of TACAN is not usually utilized by commercial aircraft. TACAN does, however, have an added navigation feature for measuring, with a high degree of accuracy, the distance of a TACAN-equipped airplane from the station. Some VOR stations without full TACAN equipment are supplied with the distance-measuring unit. Most "880" and "600" aircraft will be equipped to take advantage of this facility with DMET (Distance Measuring Equipment — TACAN).

When the VHF navigation receiver is tuned to a VORTAC station, the DMET receiver will automatically be tuned to the associated TACAN frequency. The airborne unit transmits a coded interrogation pulse to the ground unit, in the middle frequencies of the TACAN band (1025 to 1150 mc). The ground unit instantly replies, in the same code, in another frequency in the upper or lower portion of the TACAN band. The airborne receiver electronically measures the time lapse between interrogation and reply, translating this into an electrical signal for instrument use. The distance appears in a digital mileage readout of the DMET output in a small panel instrument. Accuracy should be within a sixth of a mile, or within 0.2% of the total distance. It must be remembered, when the airplane is nearing the transmitter, that the distance shown is not geographical; it is to the transmitter itself. At 30,000 feet directly above the station, for example, the DMET mileage indication will be 5 nautical miles.

Still another navigation unit will be found on some "600" aircraft to be used in overwater flights. It is a long-range navigation receiver for LORAN a system developed during World War II. Since LORAN frequencies are just above standard AM broadcast bands (1750 to 1950 kc), fixes comparable to celestial fixes are obtainable at distances up to 1500 miles from the transmitters.



INSTRUMENT LANDING SYSTEM

LORAN stations are all over the world, most of them especially placed to cover coastal waters. They are in pairs some distance apart, one transmitter being slaved to the other. Both broadcast identical 40-micro-second pulses alternately on the same frequency. By use of a cathode-ray screen, resembling an oscilloscope, the signals are matched and the time delay between the two signals determined. This provides a single line of position based on distance differential, therefore hyperbolic in form rather than straight. A second line of position is obtained from another LORAN station pair; the intersection of the two hyperbolas is the airplane position. Special LORAN charts are required to provide the line-of-position pattern for each station pair.

COMMUNICATIONS

VHF, HF, Selcal, Intercom, PA Systems

The band above VOR, 118 through 132 mc, is used for civilian VHF communication between aircraft or between aircraft and ground. Dual separate receivers, often almost identical with VHF navigation units, are provided for communication, with transmitter units added. Some airlines depend entirely on VHF channels for communication; it is limited to line-of-sight, but ground facilities are entirely adequate for domestic traffic. However, many "880" and "600" aircraft will have, in addition, a high-frequency communication receiver and transmitter, operating on frequencies from 2 to 18.5 mc, or 2 to 25 mc. These frequencies are more subject to weather interference, but the optimum range under good conditions may reach into the thousands of miles. Standard installation usually calls for one HF radio, with provisions for later installation of a second.

A recent addition to air-to-ground communications systems is Selcal (selective calling). It will be installed in a number of Convair jet airliners, and provisions will be made in others not factory-equipped.

The Selcal airborne unit is a "black box" linked to the communications receivers; when triggered by a ground signal, it sounds a chime and illuminates a panel light to let the crew know a call is being received. Once a station is tuned in, the receiver need not be continuously monitored by the crew.

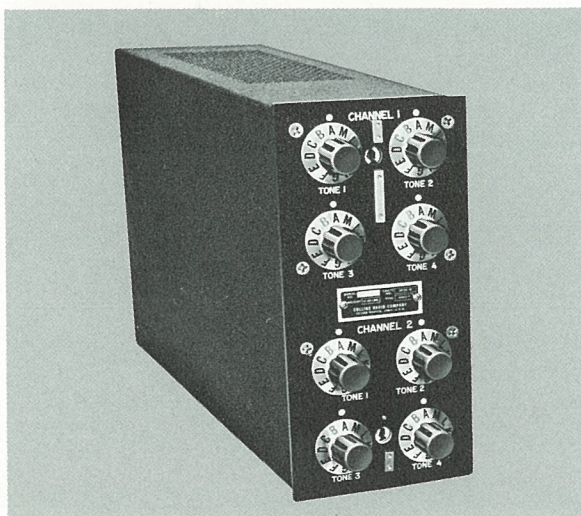
The ground station signal is a pair of consecutive audio tone pulses, each consisting of a pair of pure tones selected from a 12-tone coding system. A flight is assigned a certain sequence of tones, and the airborne unit is preset to this code. The Selcal unit can monitor two channels at once, from either HF or VHF receivers.

Audio output of ADF, VHF, or HF radio can be fed to headsets for the crew, or to a pair of loudspeakers overhead in the flight compartment. Audio selector panels are located on pilot's and copilot's consoles and on the flight engineer's panel, besides one in the electronics compartment. Microphones are provided for the pilots and flight engineer, and for emergency in the smoke and oxygen masks.

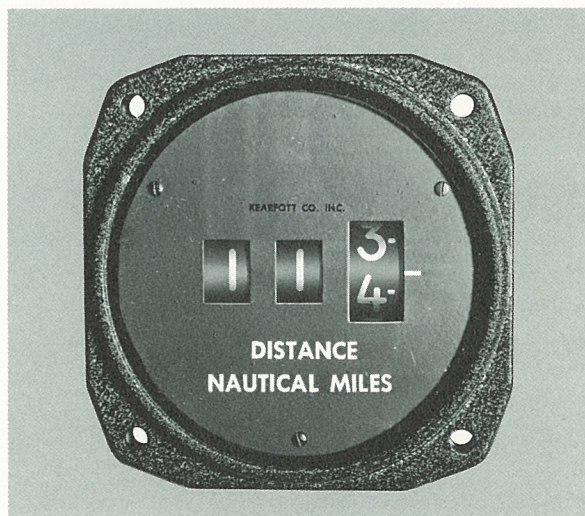
The flight compartment microphones and speakers are also usable with the airplane intercommunications system. The intercom is a "party line" system, with handsets at the stewardess stations, and jackboxes at the wheel wells, nacelles, cargo compartments and tail cone. A handset is also located on the aft face of the center pedestal, for contacting cabin stations or for public address system announcements.

The PA system comprises speakers mounted overhead in the cabin, one for each two rows of seats. Announcements may be made from the flight deck or from either stewardess station. Tape reproducers for playing music through the PA speakers are installed in some aircraft; they are located in the electronics compartment and controlled from the forward cabin station. Priority relays give priority to announcements from the flight deck, forward stewardess station, and aft stewardess station in that order.

(Part II, Radar Equipment, will appear in a forthcoming issue)



SELCAL AIRBORNE UNIT



DMET INDICATOR

HYDRAULIC GUST DAMPERS

Hydraulic gust dampers installed in conjunction with the control surfaces of the Convair 880/600 jet airliners provide a means of preventing winds and gusts on the ground from activating and possibly damaging the airplane control surfaces. This design feature does away with conventional control chocks and locks, and enables the control surfaces to swing in the wind without damage.

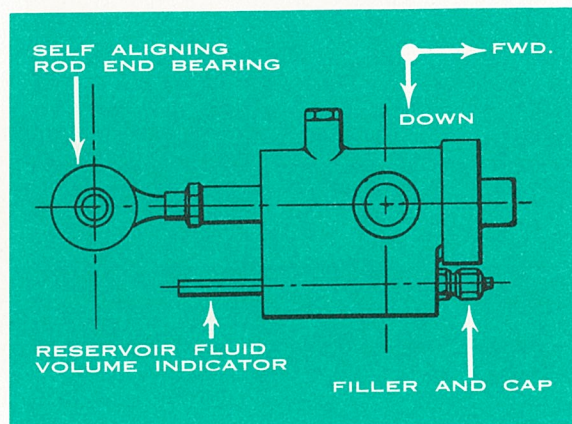
A total of five gust damper units are installed on Convair 880/600 airplanes. One unit is connected to the rudder and is located at the base of the vertical stabilizer, one is connected to each of the elevators and is located on the stabilizer spars, and one is connected to each of the ailerons and is positioned at the rear spar adjacent to each aileron.

The gust damper is a self-contained unit, requiring no hydraulic line connection to either hydraulic system. Each has its own reservoir which may be serviced with a ground cart when required. A plunger at the end of the filler connection has an index for checking the fluid level (MIL-H-5606.) The spring pressure from the spring-loaded reservoir is used to constantly service the main cylinder area if the cylinder requires fluid.

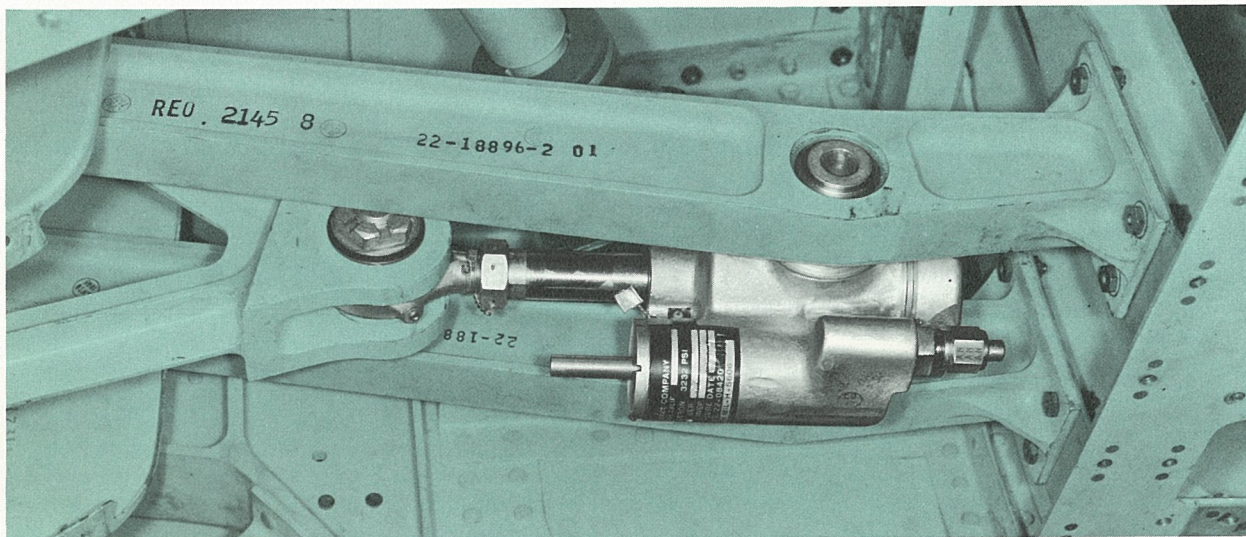
The cylinder of the hydraulic gust damper contains a piston that extends through one end of the cylinder and connects to the respective primary control surface. Small bleed orifices drilled in the piston permit hydraulic fluid to pass from one side of the piston to the other, thereby damping any ground gust load that might occur. The dampers are connected to the control surfaces in a manner that will allow the damping to increase proportionately with an increase of primary control displacement from trail.

The gust damping system of the Convair 880/600 is constantly in effect, regardless of control movement or position. However, as long as the controls are operated slowly, the damping effect of the system is negligible and does not interfere with pilot control of the airplane. The system protects the flight control surfaces against sudden, rapid movements such as those imposed by gusts and winds, and, as long as slow, coordinated control movements are executed, the presence of the damping system is not evident.

The Convair 880/600 hydraulic gust damper was designed by Convair engineers, and is currently being manufactured by the Carl Drescher Company. The configuration of the rudder unit differs slightly from those used on the control surfaces, but the principle and function of each damper is the same.



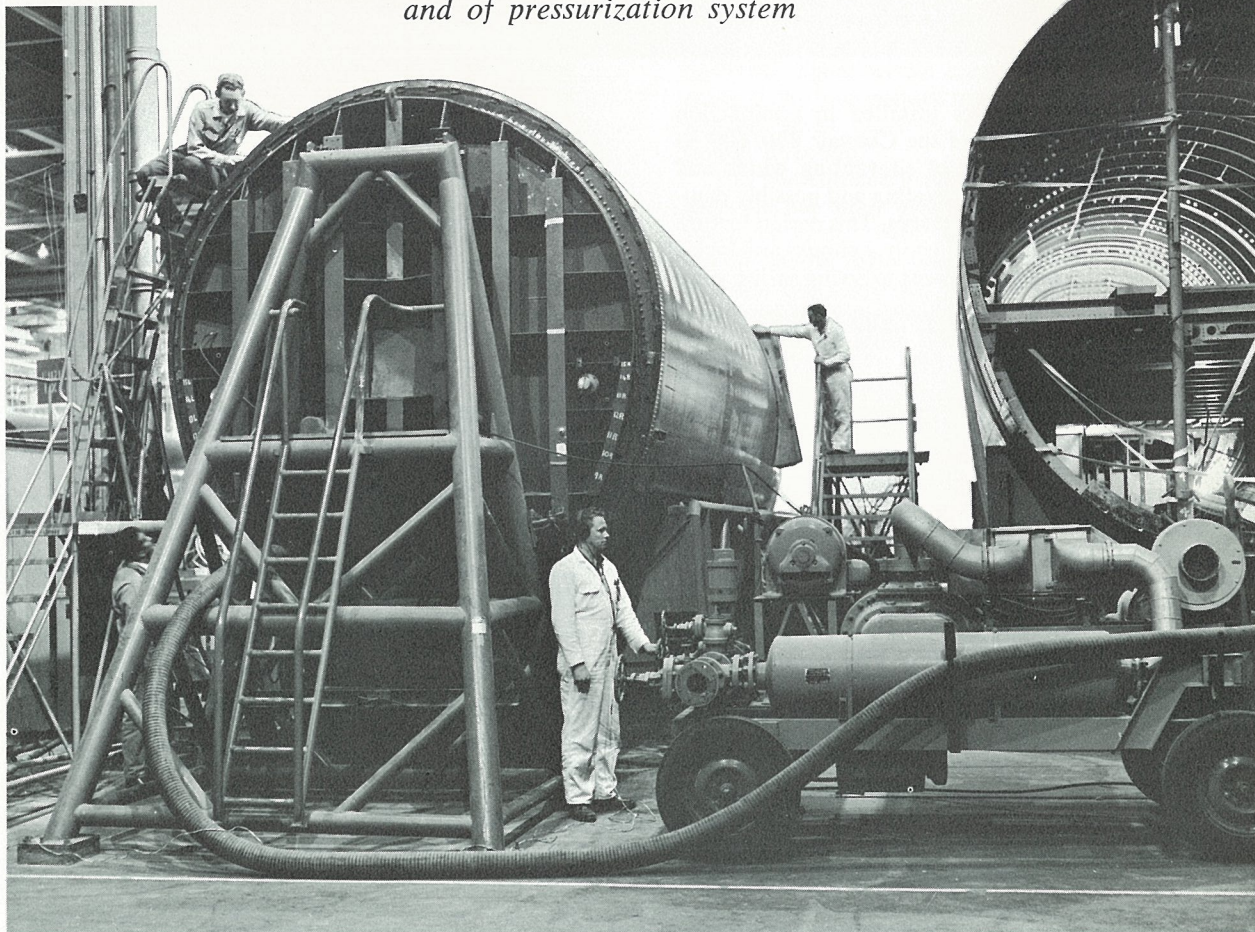
Typical hydraulic gust damper.



Hydraulic gust damper installed on "880" aileron. Unit prevents damage from sudden forces.

Convair 880 Pressurization Tests

Production pressurization tests prove integrity of fuselage structure and of pressurization system



Production pressurization test of "880" fuselage forward section.

Each Convair 880 jet airliner, as it nears completion on the production line, is subjected to thorough pressurization testing.

First of the production pressurization tests is a preliminary leakage test conducted on the forward fuselage nose section. When structurally complete, the forward section is attached and sealed to a bulkhead fixture. A differential pressure of 2.8 psig is applied, then released, after which a complete structural inspection is made. Pressure is again applied — this time to bring the pressure up to 6 psig, after which it is again relieved. Another complete structural inspection is made to determine if this loading has had any effect on the structure.

A pressure of 5 psig is then applied after which the compressor is shut off. The time it takes for the air to leak down to 4.0 psig is observed. If the pressure drops in less than three minutes, pressure differential is returned to 5 psig and held at this pressure while bubble fluid is applied externally to locate any leaks. The leaks are marked, pressure relieved, and sealant applied internally as required.

When the fuselage nose section exceeds the established leak-down time, it is ready to be joined with the remainder of the fuselage in final mating.

Final mating joins the forward fuselage section, the central fuselage section to which the wing is attached, and the aft fuselage section. When airplane mating is completed, the entire fuselage is ready for the static pressurization test.

For this test a dummy access test door is attached to the fuselage. This test door includes an air pressurization inlet fitting, connected to the pressurization test stand, a manometer fitting for attachment of the test manometer, and a safety relief valve, set to relieve pressure at 12.5 psig.

In preparation for the test, the pressure sensing ports of the cabin altimeter, cabin differential pressure, and cabin rate-of-climb instruments are capped off, because the static pressure used for the test is greater than is the normal operating pressure. Plugs are installed in the fuselage exhaust ports located in the forward and aft galley and buffet, and in the forward and aft outflow valve ports. A thorough inspec-

tion of the entire fuselage structure is made to insure that all doors, hatches, and windows are properly installed.

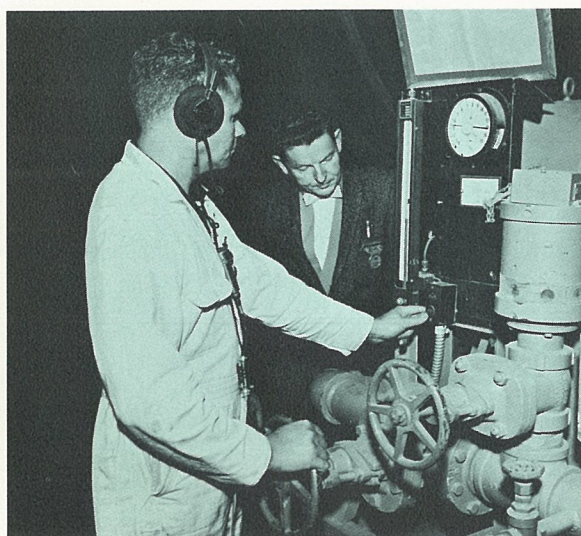
Particular care is taken to protect test personnel and the aircraft. Stout safety webbing is secured over fuselage doors and over the pilots' enclosure. Those conducting the test operate from behind a protective shield.

With all personnel, except test personnel removed from the area, air pressure is introduced to the fuselage. This pressure is built up slowly to a differential of 11.4 psig (normal operating flight differential pressure is 8.2 psig). This static test pressure is held within the fuselage for a full minute while the airplane is carefully observed for any effect this pressure might have on the structure. This test is a production line confirmation of the airplane structural strength under pressurization. The airplane is now ready for checkout under normal operating pressures.

For the remainder of the tests, personnel work both inside and outside the fuselage to check for proper functioning and adjustment of the various components of the pressurization system. The airplane's "intercom" system is used for coordinating the work.

Since the engines cannot be run on the production line, an external source of electrical power is provided. This is 115/208-volt, 400-cps, 3-phase ac electrical power corresponding to that which will be supplied by the engine-driven electrical generators.

The aircraft cabin pressurization ground test valves are placed in "Relief Test" position, and an internal pressure of 6.0 psig is applied, after which pressure is turned off. Pressure is allowed to leak down to 5.6 psig, and a time reading is taken, followed by a second time reading at 3.0 psig. If the initial time for the pressure to drop from 5.6 to 3.0 psig is less than four minutes and 10 seconds, the pressure is returned to 5.6 and maintained. Bubble fluid is applied to areas suspected of leaking. Sealant is then applied, as in the early testing of the fuselage nose section.



Monitoring pressure build-up during test.

Generally speaking, when leakage is found, it is usually around doors and door frames. These leaks are alleviated by adjustment of seals and strikers until the proper closure is obtained.

Plugs from exhaust ports for lavatory and buffet are then removed and air pressure is slowly raised to 8.5 psig so as to check automatic pressure relieving. Forward and aft cabin outflow relief valve settings are observed and checked for cabin pressure relief at 8.5 ± 0.1 psig. Airflow and operation of each of the two valves are checked.

The aircraft ground pressurization test valves are then positioned to "Differential Test." An attempt is made, by slowly raising the internal pressure, to exceed cabin differential setting (8.3 psig) of the cabin pressure controller. The controller setting for differential regulation of cabin air is 8.2 ± 0.1 psig.

With proper adjustment of the pressurization system, the cabin pressure ground test valves are placed in "Flight" position, all test plugs are removed, and the cabin pressure controller on the flight deck is set at —1000 feet altitude. This permits simulation of a flight to 1000 feet, although the aircraft is resting on the ground.

Air pressure is slowly admitted to the cabin to approximately one inch mercury on the manometer, and cabin outflow pressure is adjusted to read the sea-level barometric pressure prevailing at the time. Cabin altitude control is slowly adjusted to the "O" position, and cabin pressure ground test valves are then locked in "flight" position.

Additional checks and adjustments are made to assure that each unit is functioning as desired and that the indicators reflect this functioning.

Although the foregoing tests establish that the system and components are in proper working order, additional checking takes place during field operations, and during shakedown and subsequent flights to substantiate the integrity of the fuselage and the pressurization system.



Final pressure check of completed airplane.



CONVAIR 880 AND 600 jet airliners make extensive use of hydraulic controls. This can be appreciated by the fact that the "880" contains some 300 feet of hydraulic lines to handle the various functions actuated or controlled by hydraulics. The hydraulic fluid in these aircraft is Skydrol, a non-flammable non-toxic fluid.

Early aircraft hydraulic systems employed petroleum-base hydraulic fluids, which had one distinct disadvantage . . . they were combustible. With the growing use of hydraulic systems and their attendant high pressures, hydraulic fluid was destined to become a greater fire hazard than engine fuel. Recognizing this, the Society of Automotive Engineers issued an Aeronautical Material Specification (AMS-3150) in 1948, to establish a fluid, or mixture of chemicals, designated HS-1, to be used as a reference fluid to typify the minimum permissible fire resistance in aircraft hydraulic fluids.

24 10

Producing a hydraulic fluid that was nonflammable was not difficult, but the fluid had to have the following characteristics as well: 1) low viscosity (resistance to flow) and ability to maintain this viscosity throughout a large temperature range, from cold soaking at below zero to high operating temperatures; 2) good lubricity to minimize the wear within hydraulic components; 3) nontoxicity to permit handling with safety.

Skydrol hydraulic fluid was first introduced in October of 1948. It was the first nonflammable type fluid that not only met but exceeded the HS-1 reference fluid in its resistance to ignition. Subsequent usage in regular airline operations indicated that Skydrol was more stable than petroleum-base hydraulic fluids, and it exhibited lubricity characteristics that were superior to petroleum-base hydraulic fluids.

Skydrol is an ester-base compound that is purple in color. Its specific gravity is 1.086, which means that

its weight, volume for volume, is approximately that of water, weighing about 9.05 pounds per gallon at 60° F.

Skydrol can be ignited, but it has an autogenous ignition temperature of 1050° F; its coefficient of thermal expansion is 0.000418/° F, at temperatures of 30° to 250° F, and it has a viscosity index of 160. It has little affinity for moisture. Skydrol will absorb only 0.25 per cent of water and, conversely, water will take in only 0.003 per cent of Skydrol. It is non-volatile; is stable to heat, pressure, and altitude changes; and staves off wear by promoting longer life of hydraulic components.

Skydrol cannot be used in systems designed for petroleum fluids, because this ester-base fluid is not compatible with neoprene-, buna-, or vinyl-jacketed wiring; these rubber and vinyl compounds tend to become soft over a period of time. When in contact with most of the commonly used aircraft paints, Skydrol has a tendency to loosen or soften them. Nylon-insulated wiring is unaffected when immersed in Skydrol. Butyl rubber and epoxy paint and lacquer can withstand immersion in Skydrol with little effect. For this reason, Butyl rubber "O" rings, seals, etc., are employed, and nylon-covered wiring is installed wherever the installation might be exposed to Skydrol. Since Teflon is also impervious to Skydrol, it is used as an internal lining for the majority of hydraulic hose in Convair 880/600 installations.

Skydrol is used on Convair 880/600 aircraft for operating flaps and spoilers, main landing gear brakes, nose landing gear steering and brakes, horizontal stabilizer trim, fuel scavenge pumps, and fuel jettisoning, plus rudder boost on the Convair 600.

Through approximately ten years usage in transport aircraft, Skydrol has proved that it can be used successfully in all hydraulic operations, and that it provides the user with an additional margin of safety.

VOLUME XII NUMBER 5 SEPTEMBER 1960

Convair Traveler



In this Issue: Avionic Equipment, Part II—880/600

VOLUME XII NUMBER 5 SEPTEMBER 1960

Convair Traveler



In this Issue: Avionic Equipment, Part II—880/600

OUR COVER

Seconds ago, this "880" was dropping swiftly through a swirling fog of low clouds. It has emerged right where it should be — runway ahead, time to flare for a gentle touchdown — thanks to complex avionic systems and the men who operate them. Design by Norm Harrington, cover by Jack Davis.

Convair Traveler

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Sam Urshan

BACK COVER

HEAT TREAT GETS A DEEP FREEZE

N. V. Davidson

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Avionic Equipment - Convair 880/600

Part II: Weather radar and other electronic equipment and provisions

Airborne weather radar and an Air Traffic Control radio beacon, or transponder, are now required by the Federal Aviation Agency as standard equipment on new transports.

Airborne radar, generally familiar by now, has a transmitter which sends out a narrow beam of short high-intensity pulses from a rotating antenna. Echoes returned from objects in the path of the pulse are sensed by the receiver and translated into a visible indication on a cathode-ray screen, somewhat comparable to a small television screen. Frequency for weather radar is usually in the C-band (5400 mc), sometimes in the X-band (over 9000 mc). The antenna, a dish-shaped reflector mounted in the nose radome, rotates at 15 sweeps per minute. The area scanned covers approximately 240°, the pulses being absorbed when the antenna is turned back upon the airplane itself.

The indicator is a 5-inch screen mounted in the forward pedestal panel. A sweep line rotates with the antenna, causing bright areas to appear on the screen where the signals are echoed. In weather radar, the reflections will come from precipitation in the atmosphere.

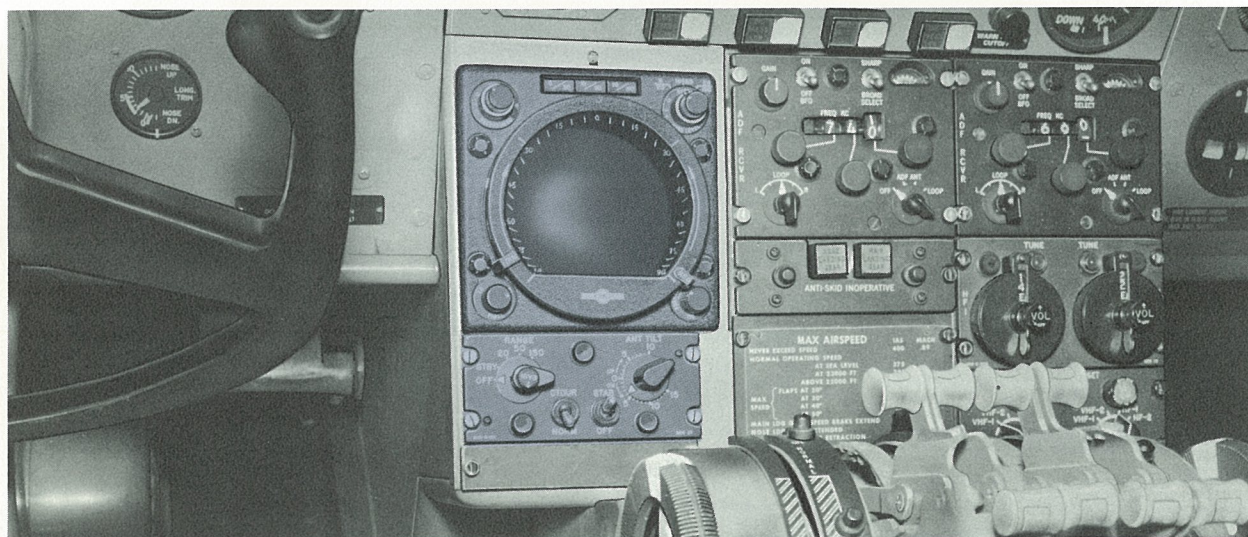
The distinguishing feature of weather radar is that the intensity of the echo signal is carefully evaluated to be reflected in the brightness of the screen, so that the brightness is a measure of the density of precipitation. It is "penetration" radar; all the echoes from within a rainstorm will be received, so that the pattern on the screen is a precipitation map of the area covered. Within a twenty-mile range, it can be made to show storm contours and rainfall gradient with a

high degree of accuracy. Since precipitation accompanies centers of turbulence in storm fronts, the weather radar has proved the most effective means ever devised for avoiding rough air with a minimal amount of detouring.

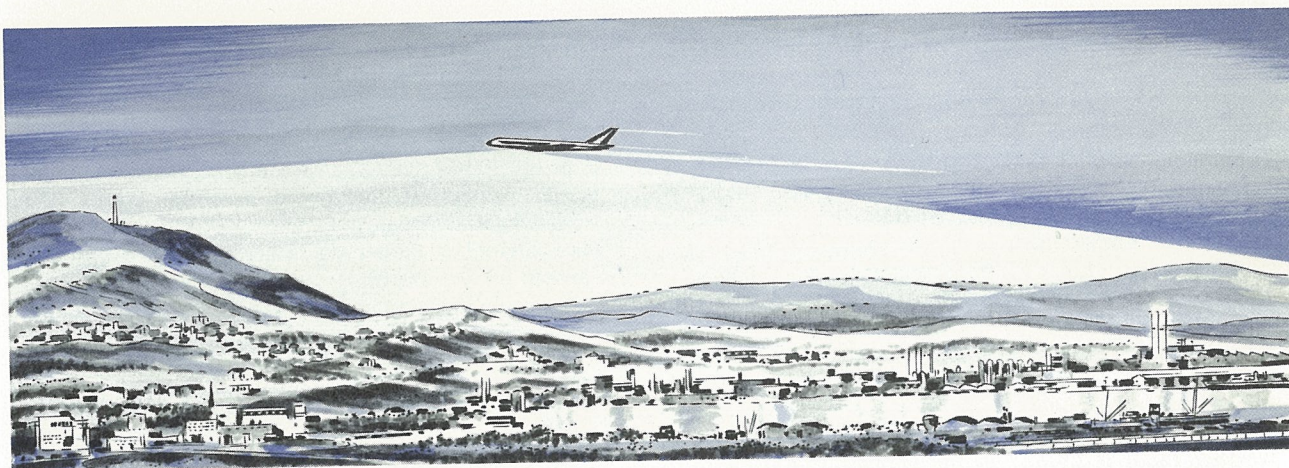
Radar weather displays, and the use of the radar for ground mapping, will be more fully described in a future issue of the Traveler.

The Air Traffic Control transponder operates in conjunction with ground radar. Airport radar is of two types: airport surveillance radar (ASR), with a 30- to 60-mile range; and precision approach radar (PAR), with a range up to 10 miles. ASR provides range and azimuth of aircraft; PAR also supplies aircraft altitude, so that airplane position can be accurately established during final approach. The operator talks to the airplane via ordinary communications radio. With PAR ground-controlled approach, an airplane can be kept on the glide path in bad weather down to the very end of the runway.

What the ATC transponder supplies is an aid to the ASR radar, as well as a coded message-bearing signal. An interrogator, coupled to the ASR transmitter, transmits a pair of pulses 8 microseconds apart on a 1030-mc frequency; the airplane replies on 1090 mc with a group of up to 8 pulses spaced to make a coded reply. The code can be set by the pilot to convey certain information — whether he is landing or enroute, or to convey other such data as may be set up in standard codes, of which 64 are available. By actuating a switch on the control panel, the pilot may add another signal for identification purposes.



Weather radar screen and control panel are on pilot's side of center console. To the right are two ADF radio panels, HF communications radio tuning controls, and Selcal control panel.



Radiating beam of terrain warning radar is fan-shaped, sweeping approximately 170° forward, down, and aft.

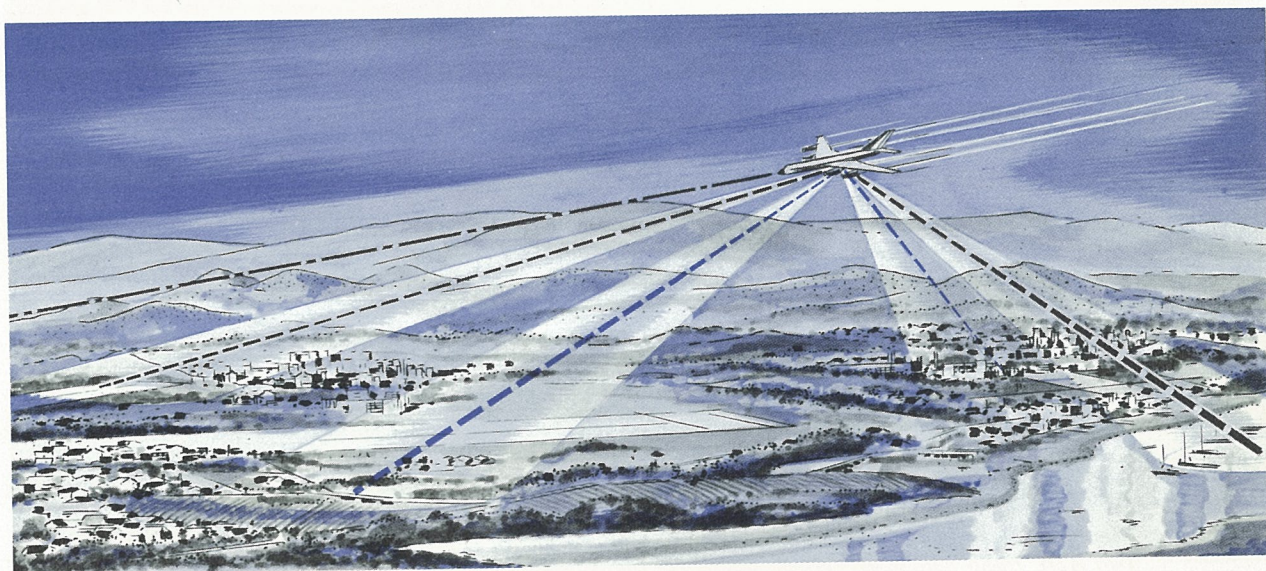
Besides the coded messages, the transponder signal reinforces the ground radar echo signal, thereby considerably extending surveillance radar range. If the airplane already shows on the radar screen, the "blip" will grow in size and brilliance when the airplane is interrogated. This makes it possible to track an airplane more accurately through weather interference or ground clutter.

A terrain warning radar, with short range, operating on comparatively low frequency, will be found on one version of the "880". This directs a 463-mc radar beam down and ahead of the airplane; if it encounters an obstruction within the range chosen, a warning light flashes and a gong sounds. The range may be selected at 500, 1000, or 2000 feet.

At least one airline has announced its intention of installing Doppler system radar in the Convair 600; provisions or space for it are in all models. This is a piloting aid that provides an accurate ground speed reading on a digital counter, together with an indication of wind drift angle in degrees.

Doppler radar depends on a phenomenon known to physicists for a century as the Doppler shift, the apparent change in frequency of a wave succession between two bodies in motion relative to each other. A ship at sea crosses more waves against the wind than with it; pitch of a locomotive whistle drops perceptibly as it passes an observer. In Doppler radar, reflected radio-frequency waves from a beam directed toward the ground ahead of an airplane return at a higher frequency than do those from a beam slanted down to the rear.

Although the number of waves per second is in billions (frequency is approximately 8800 mc), the difference between the beam frequencies is measurable electronically, and can be utilized to drive an indicator counter. In most aircraft installations, two beams are directed forward, one toward each side, and two aft. A pulse is projected simultaneously along left-forward and right-aft legs, then along right-forward and left-aft legs. The differences can be separated into components representing rate of forward motion and rate of side drift.



Doppler radar directs multiple beams forward, aft, and to each side, to sense ground speed and drift.

The great advantage of Doppler navigation is that it is completely independent of weather and ground-based aids. Dead-reckoning navigation becomes almost an exact science. Drift and ground speed are measured continuously anywhere in the world; speed accuracy is within 3 knots $\pm 0.6\%$ of the total reading, drift angle within $\frac{1}{2}^\circ$. The installation is comparatively new, but the number in use is growing.

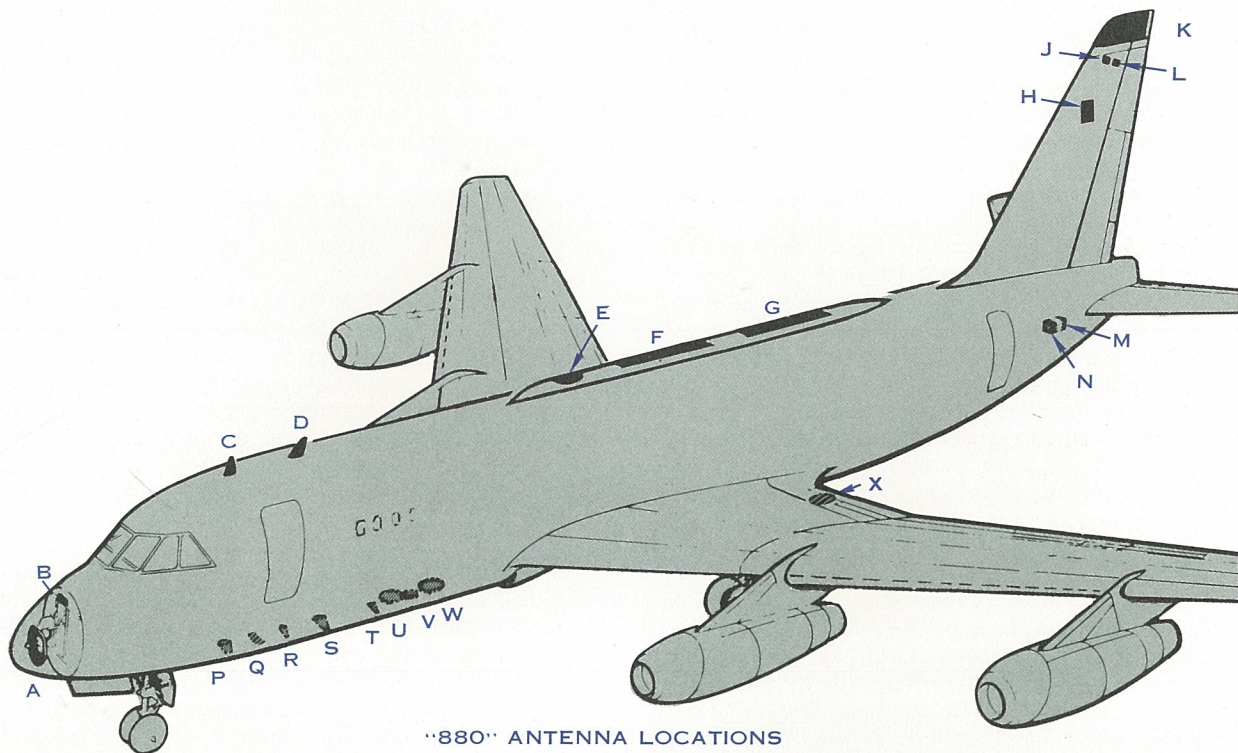
Space provisions have been requested in some aircraft for proximity warning radar and radar altimeters. The one will warn of the near presence of other aircraft; the other will supply a height above ground, rather than barometric altitude with respect to sea level.

System Components

The VHF communication, VHF navigation, ADF, glide slope, and DMET units are all dual installations, with separate receivers, transmitters, control panels, and (except for VHF navigation and glide slope re-

ceivers) separate antennas. All HF and VHF equipment has crystal-controlled step tuning. One of each pair of units is accessible to the pilot, the other to the copilot. Should the pilot's navigation radio equipment fail, he can switch his instruments and the autopilot to the copilot's VHF and glide slope receivers. The major part of the radio and radar equipment is in an electrical and electronics compartment, just under and aft of the flight deck. The compartment is accessible in flight through a door in the floor of the forward coat closet.

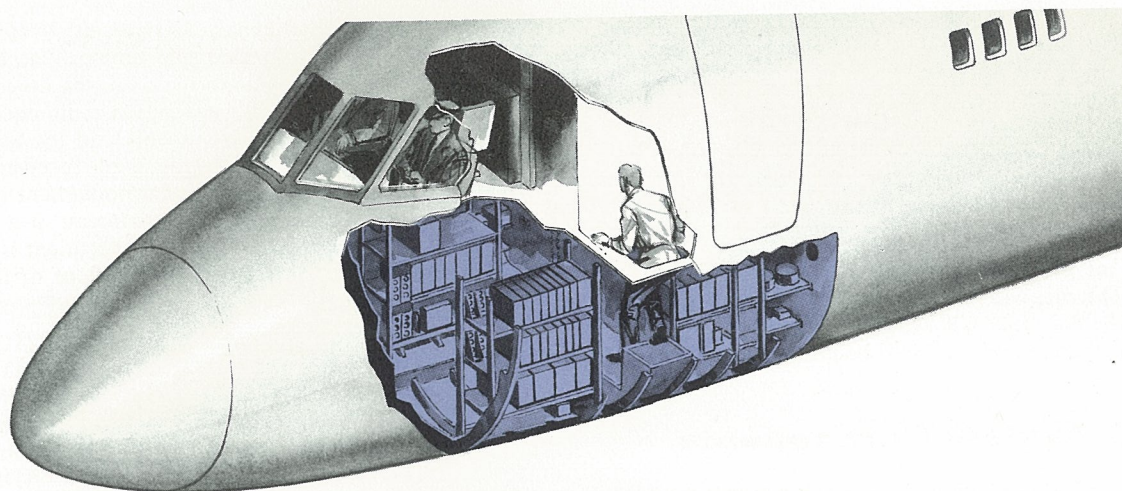
Antennas are located in the vertical fin (HF communications, LORAN, and VHF navigation); along the dorsal centerline of the fuselage (ADF sense, DMET, VHF communication and, in some aircraft, ADF loop); in the radome (weather radar and glide slope); and at the bottom of the fuselage (ADF loop, DMET, marker beacon, VHF communication, Doppler radar). Some antennas are flush-mounted in fiberglass, some are blade type. Couplers and antenna tuners are mounted near the antennas.



"880" ANTENNA LOCATIONS

A	WEATHER RADAR	M	NO. 2 COUPLER CONTROL*
B	GLIDE PATH	N	NO. 1 COUPLER CONTROL
C	NO. 2 DMET*	P	NO. 1 DMET
D	NO. 3 VHF COMMUNICATIONS*	Q	TERRAIN WARNING
E	NO. 2 VHF COMMUNICATIONS	R	NO. 1 ATC TRANSPONDER
F	NO. 1 ADF SENSE	S	NO. 1 VHF COMMUNICATIONS
G	NO. 2 ADF SENSE	T	NO. 2 ATC TRANSPONDER*
H	VHF NAVIGATION	U	NO. 1 ADF LOOP
J	NO. 1 HF COUPLER	V	MARKER BEACON
K	HF COMMUNICATIONS	W	NO. 2 ADF LOOP
L	NO. 2 HF COUPLER*	X	DOPPLER RADAR*

*PROVISIONS ONLY



Electrical and electronics compartment houses racks of "black boxes," with room for more when needed. In-flight access is through floor plate in forward coat closet.

Providing for the Future

Contemplation of this array of electronic equipment, with controls all concentrated in one compact-as-possible flight compartment, leads to a suspicion that a saturation point is rapidly approaching. The airplane may hold more, but there won't be enough crew to man it.

This factor is recognized by the commercial and Federal agencies concerned. However, the present pattern of the airways system is nearing a goal set some years ago; not that airway facilities will cease to change, but that there should be a relative stability for a certain length of time. The basic electronic configuration of the Convair 880 and 600 aircraft will probably continue to satisfy all essential requirements for some years to come, perhaps through the 1960's.

There is one exception: one system, still in process of development, is expected to be ready for use in the foreseeable future, perhaps by 1962. It is presently designated AGACS (pronounced Ajax), standing for Automatic Ground-Air Communications System, and it is regarded as today's most pressing development program involving airborne electronic components.

It is well known that airports daily become more crowded — complex radar-computer units are being installed, some experimentally, in large airports to keep track of arriving and departing aircraft. Ground radio control rooms reflect the rush of airway business by becoming overloaded with communications. Even with multiple channels and crews to man them, there is sometimes more talking to do than there is time.

It is believed that a relatively compact airborne unit, together with corresponding ground facilities, can relieve the congestion of communication radio channels. A sizable proportion of air-ground communication is concerned with enroute flying, rather than with airport takeoff and landing. It consists of requests, or instructions, for altitude or route changes, weather reports, flight clearances, and the like; and

routine reporting of position, altitude, and flight plan estimates. On our airways today, every commercial and military flight is monitored from the ground from takeoff until landing. The enroute data must be recorded, evaluated, and often passed on to other facilities. Even so, there is constant pressure to keep even closer track of what is flying and exactly where.

AGACS proposes to set up a coded signal system to remove the routine transmission of data from voice channels. Currently, the program is in proposal and research stage only. It has been established, however, that a ground station using only one channel could record flight altitude, for example, of 500 aircraft every two minutes. In one proposal, 32 coded messages would be available for reports and inquiries between airplane and ground, any of which could be transmitted within 24 milliseconds.

Another system, developed and proposed by Stromberg-Carlson, a division of General Dynamics, would transmit preselected messages at only 1/15th the rate per bit, but would permit simultaneous voice and data transmission, and could also be tied in directly with teletype circuits. Whatever the final choice, AGACS equipment would be made compatible with ground computer and relaying systems.

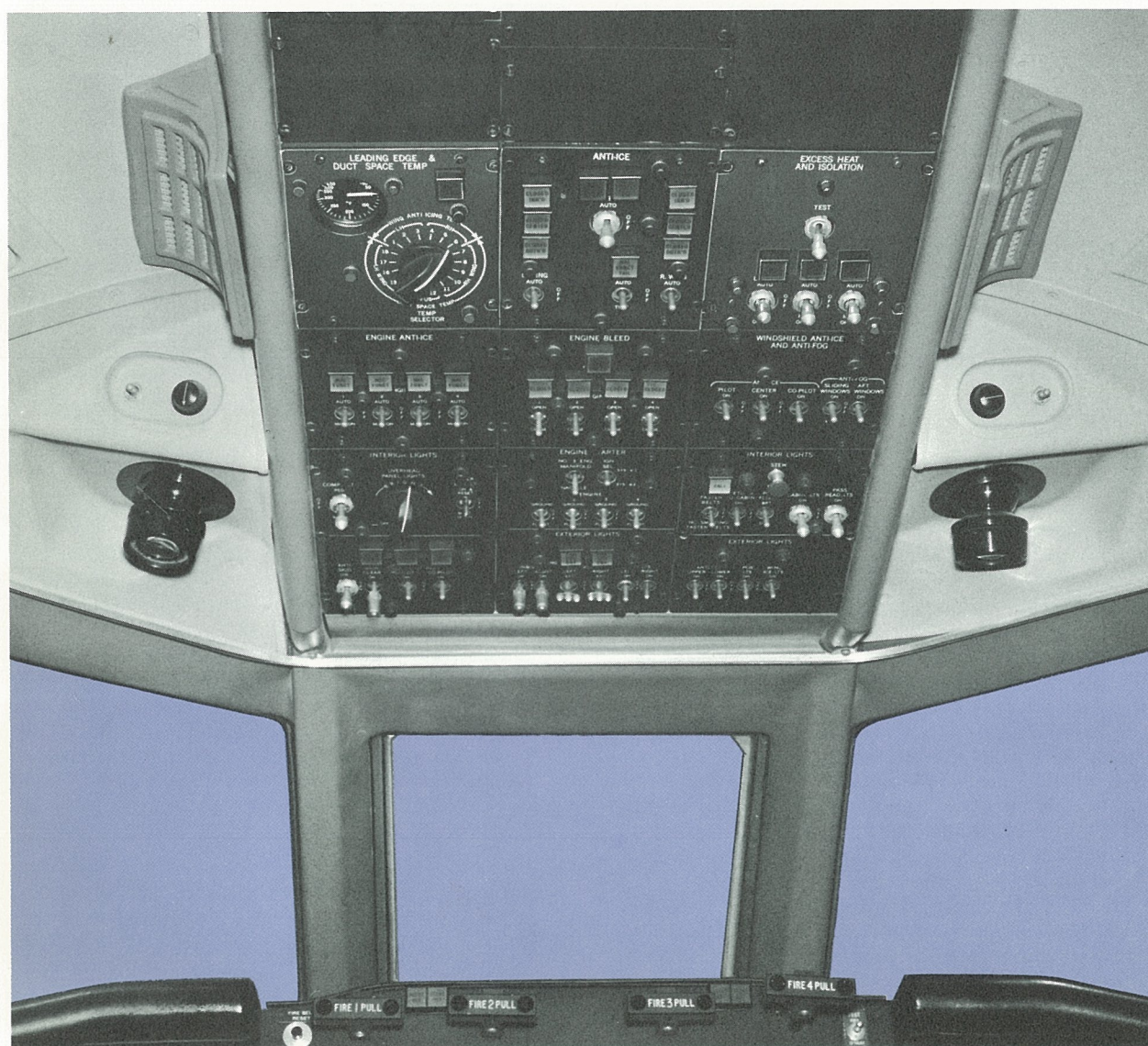
The plan is to utilize VHF and lower UHF frequencies. It may be possible to use transceivers already in the airplane, with additional units for computing, encoding and decoding, and for making the information available. However, just what equipment will be required, and how much information will be exchanged, has not yet been settled.

Under the circumstances, the only provision for AGACS that could be made in the Convair 880 and 600 was to leave space for it. This is available. Even with the dozen and more radio units, LORAN, weather and Doppler radar, and other assorted installations already in the airplane, there will still be space for more if or when it is required.

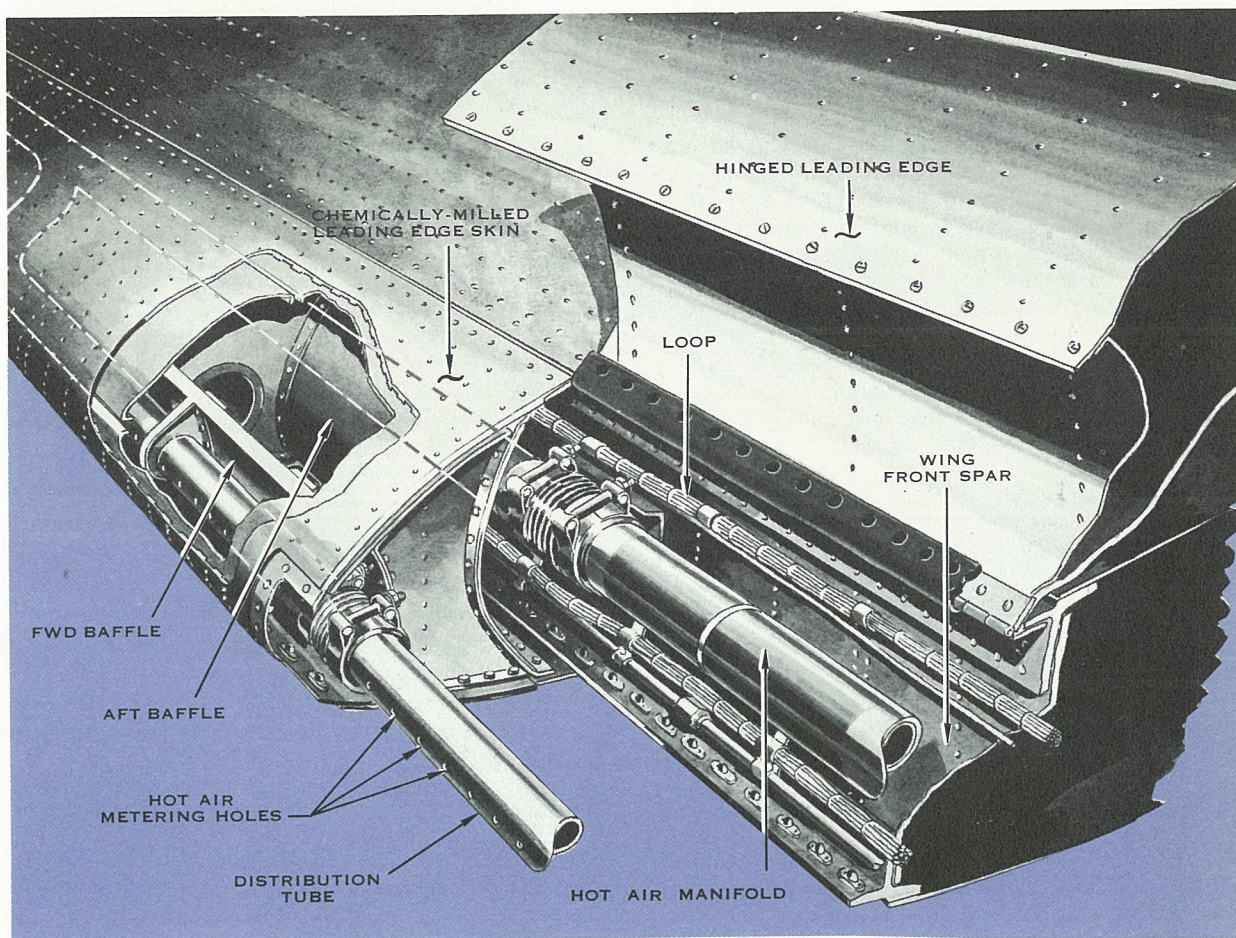
Excess Heat & Isolation System Convair 880/600

The front spar of the Convair 880/600 wing has a structural design temperature limit that must be maintained to assure integrity of the structure. Hot air, bled from the engines (used for anti-ice, rain clearing, and other systems), is routed through ducts that pass between the spar and leading edge of the wing. Under normal operating conditions, excessive heating of the spar is prevented by insulation, which covers the bleed air ducts. Should the bleed air duct insulation become damaged or develop a leak, the wing structure could become overheated, if preventive measures were not incorporated in the "880/600" design.

The safety feature, which protects the wing structure in the area of the bleed air ducts, is the excess heat and isolation system. This system consists of heat detecting loops installed in the duct spaces of the wings, engine pylons, and fuselage; a control panel and a control box. The control panel, labeled "EXCESS HEAT AND ISOLATION," is located on the pilots' overhead switch panel and is fitted with EXCESS HEAT warning lights, control switches, and a TEST switch. The control box is located in the electronics compartment and consists of a relay box and magnetic amplifier control units.



Pilots' overhead switch panel contains control panels for excess heat and isolation system.



Wing leading edge section showing exhaust hot-air chambers.

The excess heat and isolation system is divided into as many sections as there are heat detection loops — the number depending on customer requirements — and monitors left wing, fuselage, and right wing. Each section has an AUTO and MAN OPEN control switch for automatic or manual operation, and an EXCESS HEAT warning light on the EXCESS HEAT AND ISOLATION panel.

If the alarm point of the wing spar sensor should be reached, one of the red EXCESS HEAT warning lights will illuminate to indicate the area of excessive heat and, if the control switch to that area is in the AUTO position, the isolation valve in the applicable duct will automatically close the bleed air flow to the area of the leak, or break.

The normal position of all switches is AUTO. If the control switch is in the MAN OPEN position during excessive heat conditions, the EXCESS HEAT warning light for the heated area will still illuminate, but the automatic protection from excessive heating will be bypassed. Without this automatic protection during excessive heat conditions, possible overheating of the wing structure could result.

Manual override of the isolation valves is used at the pilot's discretion; for example, anti-icing a wing despite some degree of duct space overheat. Should this condition exist, duct space temperature can be monitored by the use of a multi-position switch and a temperature indicator located on the LEADING EDGE TEMP panel. This information is supplied by 5 duct space sensors spaced along the front spar in each wing. Two other duct space sensors are located in the fuselage in the immediate area of the forward and aft rainclearing duct. Manual override might also be used to close the isolation valves in the event the bleed valve fails to respond to an overheat signal.

The heat detecting loops have a normal impedance of more than one megohm between their inner and outer conductors. When they are heated to a temperature that reaches their alarm limit, the impedance is greatly reduced and in turn is reflected in a control winding of the magnetic amplifier which influences a signal that actuates the applicable isolation relay.

If one or more inches of a heat detecting loop is subjected to a temperature that reaches its alarm limit,



Wing leading edge anti-ice air flow (typical).

it will actuate the corresponding EXCESS HEAT warning light on the EXCESS HEAT AND ISOLATION panel. With the system operating automatically, a warning from a wing section will close both engine bleed air valves on that side, and the correlative isolation valve. A fuselage section warning will close both wing isolation valves.

To prevent the loss of pressurization due to EXCESS HEAT in the fuselage section when both wing isolation valves would close (in AUTO mode), the pressurization turbocompressors are supplied from a point outboard of the wing isolation valves.

The TEST switch on the EXCESS HEAT AND ISOLATION panel is used to check out the heat detection circuits. When all the heat detectors, relays, and control units are operating properly, switching to TEST position will illuminate all EXCESS HEAT warning lights. With the test switch in TEST and the control switches in AUTO, the entire bleed air system will be isolated and will remain so until the control switches are moved to OFF and then back to AUTO or MAN OPEN positions. With the control switches in OFF or MAN OPEN, the bleed air sys-

tem will not be affected. Releasing the TEST switch will extinguish the EXCESS HEAT warning lights.

The isolation control switches are normally in the AUTO position. When an EXCESS HEAT warning light illuminates, it indicates the section of excessive heat, and isolation of that section automatically goes into effect. A check for the proper isolation of the indicated overheated section can be made by moving the corresponding control switch to the OFF position. If the temperature is back to normal, the EXCESS HEAT light will go out; if the section is still overheated, the light will remain on.

The temperature of the wing duct spaces may exceed the heat detector alarm limits during ground engine run-up with high bleed air flows, because the alarm temperatures are based on in-flight conditions, where ram air cooling is present. Therefore, isolation and warning systems for the left- and right-hand wings are rendered inoperative through an interlock, whenever the landing gear ground safe relay is energized. This feature prevents the excess heat isolation system from cutting off the bleed air supply erroneously while the airplane is on the ground.

Convair 600 Engine and Pods

The General Electric CJ805-23 aft fan turbojet engine, which will be used to power the Convair 600, is almost identical to the CJ805-3 engine, which powers the Convair 880, except for the addition of the aft fan.

Mated to the rear of the basic CJ805-3 engine, this unit is a free wheeling, single-stage fan that functions in a manner similar to that of a propeller, driven by engine turbine exhaust gases.

The operation of a fan, or bypass, type engine is the same as that of a conventional turbojet engine with utilization of additional inlet airflow ducted around the engine. The fan assembly, driven by engine turbine exhaust gases at its root, compresses the bypassed air with its outer blades, and discharges it with the exhaust. This action increases mass airflow which results in a large increase in overall engine thrust. The aft fan turns approximately 5760 rpm — 75 percent of engine rpm.

At sea level takeoff power setting, this engine provides 43 percent thrust increase with no increase in fuel flow over that of the -3 engine, a 20 to 40 percent improvement in climb thrust, and a 4 percent improvement in cruise thrust. In addition, a natural reduction in engine noise level is achieved, eliminating the need for engine exhaust sound suppression devices. Since the CJ805-23 aft fan engine discharges a larger mass of airflow at a lower jet velocity, there is less violent mixing of the exhaust and the surrounding air — the cause of most of the engine exhaust noise.

The aft fan design offers the least amount of compromise of the basic gas generator performance. The easy starting characteristics of the CJ805-3 engine are retained in the aft fan CJ805-23, and the acceleration characteristics of the aft fan engine — from idle to maximum speed in approximately 5 seconds — are almost the same as those of the straight turbojet engine.

In integrating the bypass ducts, the pod configuration of an aft fan engine can take several shapes, three of which are the single (combined engine-fan) inlet, the cheek-type inlet, and the annular (aft) inlet. Convair chose the single inlet design which produces the least drag of the three configurations. A forward concentric inlet is not only superior aerodynamically, but also is less apt to ingest foreign matter into the engine from the runways.

The pod, which contains the engine and the airflow ducts, is supported by a pylon which extends forward

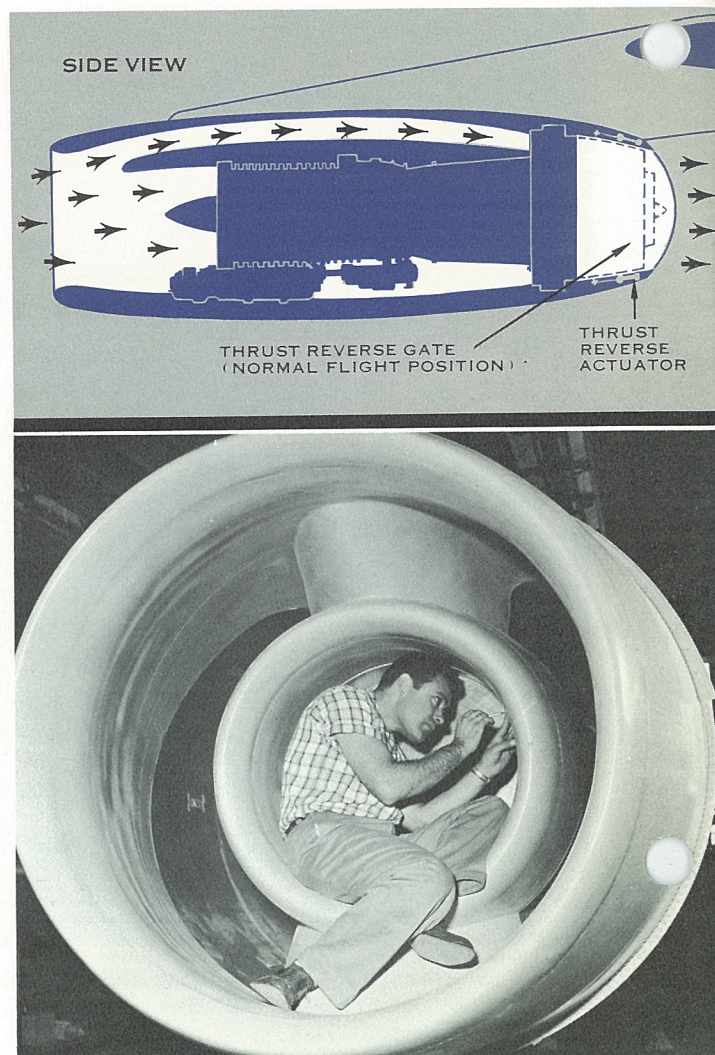


Photo shows comparable sizes of airflow duct and engine duct. Combined inlet configuration reduces drag.

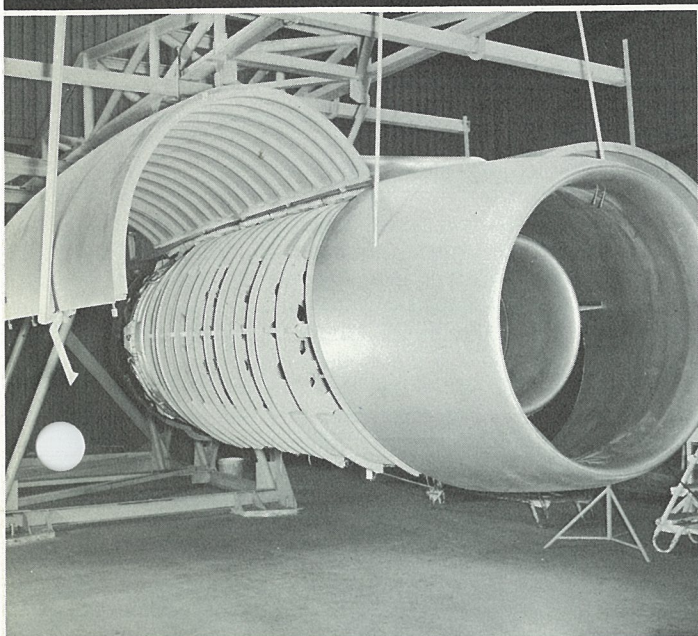
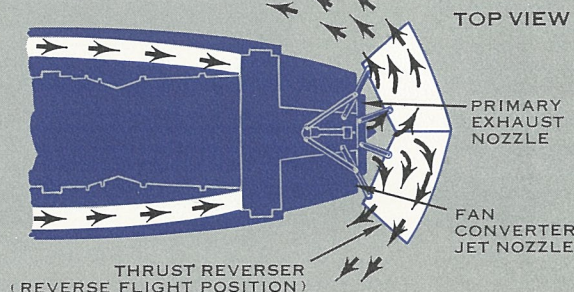
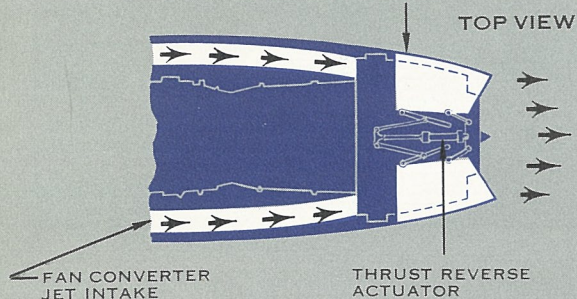
and downward from the lower surface of the wing. The inboard and outboard pylons are located at B.L. 266 and B.L. 495.5 on each wing. To minimize drag, the aft end of the engine is located in line with the intersection of the wing leading edge and the pod vertical center line.

Each pod and its contents form an independent unit — a complete power source. The engine and its assemblies are interchangeable in any of the four positions.

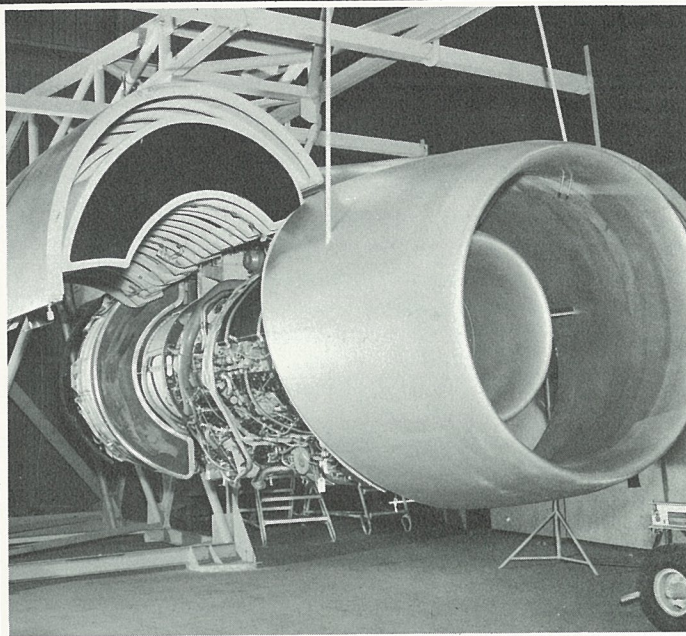
The "600" pod, constructed of aluminum, steel, and titanium, is made up of six main sections: the nose cowl, the upper fixed pod structure, the two door panels, and two hinged fan ducts.

The inner and outer skins of the nose cone section are made of aluminum with formed aluminum frames. The leading edge of the nose cowl is dynamically etched to form lands that provide a space between the inner and outer skins for engine bleed air anti-icing.

GATE (TARGET TYPE) THRUST REVERSER
(NORMAL FLIGHT POSITION)



"600" engine pod mock-up shows hinged door in open position. Door can be opened while engine is running.



Fan ducts in the "600" engine pod are hinged on each side and can be opened for easy access to the engine.

The pod doors combine aluminum and steel formers, and are skinned for the most part with aluminum. Titanium is used for firewalls and in areas of proximity to hot engine components. The hinged fan ducts have aluminum frames and skin.

The fan ducts and the doors of the engine pod are hinged separately on each side of the upper pod structure. Separating the doors from the ducts permits the doors to be opened independently for adjustment and maintenance of the lower accessories, while the engine is running. Duct screens are not required with the ducts in place.

The thrust reversers for the "600" are designed specifically for the CJ805-23 engine by General Electric, and are an integral part of the power plant. They are of the simple, fast-acting, target (clam shell) type, and provide approximately 40 percent reverse thrust with a minimum of re-ingestion.

A pair of blocker doors (clam shells) rotate and move aft to the closed position so as to divert the exhaust gases forward. When stowed, the blocker doors fit around the concentric exhaust outlet to form the aft end of the pod.

The thrust reverser system is actuated by links and lever arms, powered by two hydraulic actuators, and is operated with the same controls and in the same manner as that on the Convair 880. The thrust reverser actuators are accessible for service and can be removed with the engine installed.

The reverser is designed to extend in two seconds and to retract within six seconds. It is intended to be operated on the ground only at airplane speeds of 60 to 200 knots.

Provisions are made for ease of ground servicing, routine maintenance of engine and accessories, replacement of parts, and complete engine changes.



Heat Treat gets a Deep Freeze

Man, probing into supersonic flight speeds, has encountered frictional heat; his probings into the fringes of space have indicated that he will encounter extreme cold. This has pointed up the need for stronger materials that will withstand the rigors of these temperature extremes.

Two stainless steels, 17-4PH and 17-7PH, have been developed and have already been proved in the Convair-built F-106 aircraft. The Convair 880 has made some use of these alloys; Convair 600's will use even more of these steels — the largest usage being for the new aft fan engines.

The 17-4PH steel is used primarily in bar stock form for machined parts, because of its nearly equal longitudinal and transverse ductility. This steel receives what might be regarded as a normal heat treatment. Unlike 17-4PH, 17-7PH is obtained in sheet and plate, and is used where bending, forming, and welding are required. Its thermal treatment includes a deep freeze at minus 100°F.

Usually, heat treating involves "soaking" the steel or other metal at elevated temperatures. A first soaking is often applied to anneal, or soften, the material so that it can more readily be worked to shape. Then, a second soaking is sometimes applied to relieve stresses set up by working or welding, and perhaps a third to develop the full strength potentials of the finished part. In the case of the 17-7PH stainless steel, however, it is "cold soaked" during one phase of its heat treatment at minus 100°F for a period of eight hours.

While cold soaking at such a temperature may not indicate *heat* treating, it actually is. At minus 100°F, the material is being exposed in small degree to heat. On this basis, it can be said that the steel part is being heat soaked and hence is being heat treated, even though the thermal temperature is minus 100°F.

Sheet stock 17-7PH steel is received in the annealed condition and is relatively non-magnetic. The material is stretch-formed, or cold worked, which tends to harden the part. It is re-annealed (1950°F), if necessary, to remove hardening for further forming.

Following this, it is given an austenite conditioning treatment at 1750°F for three minutes for each tenth

inch thickness, and is then air-cooled. It can be re-formed at this point, if necessary.

The deep freeze, at minus 100°F, takes eight hours. During this time, it is generally placed on a fixture to obtain "guided growth." Oddly enough, 17-7PH will expand approximately 0.005 inch per inch. As an example, a part 10 feet long would actually grow ½ inch in length. A metal structure change takes place; technically, this is a change from the austenitic (its received) condition to a martensitic condition.

It is then given a precipitation hardening treatment at 1050°F for one to two hours, depending upon the thickness of the material. This relieves internal stresses from the change to martensite and, at the same time, has a hardening effect. During the heat treating, as outlined, the steel becomes somewhat magnetic.

Without being too technical, the following figures show the effect of the deep freeze.

CONDITION	TENSILE STRENGTH		MINIMUM ELONGATION % in 2"
	YIELD PSI	ULTIMATE PSI	
MIL-S-25043A	150,000	180,000	6.0
No Deep Freeze	155,000	185,000	7.0
With Deep Freeze	160,000	200,000	10.0

The increase in the tensile yield, ultimate strength, and elongation is obvious. Increase in elongation means an increase in toughness, which increases resistance to shock loads and fatigue. Corrosion resistance is also enhanced.

The foregoing values do not express the highest strengths that can be achieved with this particular stainless steel. By another treatment, average strengths to 230,000 psi ultimate yield have been produced; however, the elongation percentage drops. With this gain in strength, the metal becomes more brittle and less resistant to shock.

The 17-7PH steel parts fabricated and heat treated, employing the deep freeze operation for the Convair 880 and 600, will contribute to the long life being built into these aircraft, by providing strong, tough, corrosion-resistant parts to do the job.

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Convair Traveler



In this Issue: Convair 880 Winter Operation



OUR COVER

Artist Jack Davis portrays an "880" in winter mantle as preflight crews ready her for flight. This scene will soon be repeated as Convair jet airliners begin their first winter of airline operation.

Convair Traveler

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DRIP STICKS
Sam Urshan

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Cold Weather Operation

Convair 880

Apart from its size and jet engines, taking care of a Convair 880 in cold or stormy weather is little different from servicing and maintaining any transport aircraft under such conditions. Snow and ice will still have to be removed by the best means at hand, controls freed and cold-soaked airplanes carefully prepared for flight. The techniques and cautions necessary are new only in details.

Some of these details — the distinctive features and individual characteristics of the “880” — are presented herein as Convair’s jet airliners begin their first winter of airline operation. Along with some general discussion of cold-weather maintenance are some precautions to be taken when subfreezing weather is anticipated, with some data on ground de-icing and on systems in cold-weather operation.

PREPARING FOR BAD WEATHER

When reports forecast storm or extreme cold, or when an “880” is to be parked for any length of time outdoors, extra care should be exercised to see that the airplane is “buttoned up” for winter.

Flaps and spoilers should be retracted and horizontal stabilizer trim set at approximate neutral. This is standard flight handbook procedure after flight before engine shutdown, but is doubly important in bad weather. If precipitation is expected, it is a good idea to raise the stabilizer leading edge to neutral and then return it about 2 degrees; this rolls down the tubular silicone rubber seal, so as to prevent forming a trough in which water might freeze, or from which it might run down into the tail cone.

Batten-type gust locks for control surfaces are not advised; the gust dampers should provide adequate protection against wind damage.

All covers for engines, air conditioning system intakes, pitot and static intakes and ports, and ram air

inlets should be in place. Small covers should be conspicuously marked or tagged so that they are not likely to be overlooked before flight. Most covers can be left on during any ice or snow removal; if takeoff is to be made in ice or snow, they should be removed at the last possible moment.

Water and waste systems should be drained. Best method for water system drainage is to operate the pressurizing pump (by ground cart power), open all lavatory and buffet valves and faucets, and blow out the lines, making sure that water heaters, water coolers, and filters are drained. If pressurizing is impossible, the systems are so designed that lavatory and buffet faucets can be opened while the tank drains to siphon most of the water from the lines. The waste system requires simply draining and flushing; there are no traps to clear.

If the airplane is to be parked in snow or icing precipitation, particularly for just a few hours, it sometimes saves time and manhours to paint around doors and frequently-opened access panels with one of the inhibited glycol anti-freeze compounds (described in next section). The glycol will, of course, soon dilute and wash away, and must be reapplied at intervals. It may be painted on surfaces under snow covers to prevent the cover freezing to the surface. It can also be used full strength on wing or tail surfaces themselves to prevent frost. However, if snow is expected, painting exposed surfaces is rarely useful, since the slush that forms will be more troublesome than dry snow.

Another timesaver can be parking the wheels on planking rather than on ice or packed snow, or when sleet or slush may be expected to freeze tires to the ground. If sand or cinders are used for such a purpose, it should be confined to wheel areas and not distributed where it may be drawn into the engines on starting.



"880" in Alaska during cold weather shakedown.

DE-ICING

Nearly always, the best way to remove snow is to sweep off as much as possible. A classic method, useful on the "880" as elsewhere, is to throw a line over the fuselage and drag the snow off. On wing and tail, use a brush or broom and exercise care not to damage vortex generators.

Snow seldom comes off quite clean; a certain amount usually freezes to the surface. It is as important on the "880" as on any aircraft to be sure that the surfaces are entirely free of ice before takeoff, even dry if possible, particularly on empennage and wing.

Most military and many commercial facilities have spray equipment for applying de-icing fluids, which are usually diluted with water and sometimes heated. Glycol anti-freeze compounds, often identified by military specification numbers, have been materially improved. The compound currently used by the Air Force and recommended for commercial use is MIL-A-8243A. This is ethylene glycol and propylene glycol in approximately 3:1 ratio, with added corrosion inhibitor and a wetting agent. It has low toxicity, causes no damage to aircraft metals, and has no effect on most plastics, paint, or rubber.

Inhibited ethylene glycol (MIL-E-5559) is not corrosive to aircraft metals but may stain painted and plastic surfaces, including windows. Uninhibited ethylene glycol is somewhat corrosive, particularly to magnesium.

The alcohols (including glycerine), most petroleum products, and most solvents will stain or damage cabin windows. Only solvents specifically designated or tested for use with acrylic plastic should be used to clean "880" windows. The radome, however, is epoxy-coated and is resistant to glycols and most solvents, except that petroleum compounds are generally injurious to the rubber in de-icing boots.

When used cold for de-icing, glycols can be sprayed on full strength every fifteen minutes. MIL-A-8343A can be used to keep slush from sticking during takeoff roll. Locally applied, it must be brushed on until it wets the surface. Diluted, it can be sprayed hot at temperatures from 180° to 200°F. It has a flash point somewhat above 200°F and should be handled carefully around heaters. Since it may cause scaling of concrete, a coating of linseed oil is recommended to protect ground surfaces.

The vortex generators forward of the ailerons and rudder can be damaged in de-icing, either from excessive spray pressure or from impact. Because honeycomb panels have fairly thin skin, beating ice off with knotted cords or hose is not advised. Tools should never be used to pry or gouge at ice layers.

If hot air is used for de-icing, particularly from a ground starter unit, skin areas should not be overheated. A large flow of warm air is more effective than a blast of hot air. Any temperature under the boiling point of water is safe.

Should the last layer of ice or snow be melted from the fuselage, or from the leading edges of the wing, by internal heating from ground sources, the water will probably run down and refreeze in unheated areas, and must be removed again. If hot air is put through the wing anti-ice systems, heat should be cut off as soon as the ice is loosened. The empennage leading-edge electrical de-icing system is designed for in-flight use only.

Whatever the de-icing method, inspection should be made of the trailing edge mechanism areas of wing and tail to be sure that water or slush has not run down inside to refreeze. Glycol solutions will freeze when

sufficiently diluted. No chemical damage from glycol compounds is anticipated. Drain holes in under surfaces should be checked.

Aircraft with movable horizontal stabilizers have one extra area to protect against adverse weather—the tail cone area. In the “880”, a rectangular opening through the fuselage skin is large enough to allow the stabilizer interspar structure to pass through the fuselage. Rubber seals attached to vertical blades, above and below the stabilizer, rub against the fuselage. Any misfit of the seal may allow water to run into the tail cone. Normally, this will drain out through a pair of half-inch holes at the forward end of the tail cone. It is well to check that the drain holes have not been closed by ice or foreign matter.

Before operating aileron, elevators, and rudder from the flight deck, they should be moved manually through their full ranges to be sure they are free. Flaps and spoilers should not be operated until all external ice is removed. In the vertical stabilizer, particular attention may be required around balance board areas of the rudder nose, and also at the sideslip sensor inlet ports. These are half-inch holes on each side near the stabilizer nose (WL 241, 11% chord). The holes open into a small box chamber, which is normally drained but which might fill and freeze under certain conditions, and then would require heat to de-ice.

“880” SYSTEMS

PROPULSION:

The CJ805-3 engine should be easier to operate in even very bad weather than the average piston engine. Jet engines do not require oil dilution, propeller deice, priming, or lengthy warmup.

Engine compressor rotors should be checked to see that ice has not formed inside. This is particularly necessary when engines have been shut down in driving rain or falling snow.

Starting time may be a few seconds longer, but there should be no difficulty in lightoff or bringing rpm up to idle. Engine starts should be closely monitored to ensure that oil and fuel systems operate normally.

FUEL:

In comparison with aviation gasoline, JP-4 and kerosene, currently the standard fuels in commercial jet operation, have greater affinity for water. As long as water remains in solution, it does no harm. It becomes a problem only if it precipitates and freezes, when it tends to clog screens, filters, valves, or pumps.

The “880” fuel system, and the fuel heaters in the engines, have been thoroughly tested to prove they could handle anything but an extremely abnormal suspension of water and ice in fuel. Nevertheless, winter operation requires an extra close watch to see that fuel is uncontaminated.

There are nine drains for tanks, lines and pumps in each wing. They can be checked after a flight, when the water has had time to settle, and they certainly should be checked before flight. Condensation from fuel already aboard can best be removed before refueling stirs it into suspension. If drains are frozen, heat must be applied long enough and over a large enough area to thaw any ice accumulation in the tanks.

It may be noted that the Convair test program included an exhaustive checkout of all essential units of the fuel system upstream of the fuel heater, at laboratory temperatures down to -40°F , including

During cold weather tests in Far North, Convair 880 proved capabilities under freezing conditions.



tests with water-saturated ASTM Type A kerosene to which was added two cubic centimeters of water per gallon of fuel. At this temperature the pumps handled the fuel without difficulty, and lines remained open.

HYDRAULICS:

At low temperatures, Skydrol 500A becomes somewhat more viscous. Precautions should be observed to warm up the systems before full operation. Engines should not be operated at more than idle speed until hydraulic fluid temperatures are above the 0°C red line, primarily because of the possibility of pump cavitation from lack of pressure in the pump supply lines.

For cold weather starts, the procedure is as follows:

1. Check reservoir level.
2. Turn on auxiliary pump as usual before engine start.
3. Start engine and hold at idle rpm.
4. Turn on temperature control valve and cut off auxiliary pump.
5. When systems are warmed, operate controls and hydraulic mechanisms slowly, to clear low-temperature fluid from the lines.

LANDING GEAR:

As in all aircraft with airsprung struts, landing gear strut compression will increase as temperature falls. Whether the struts should be reinflated to prescribed extension may depend on whether the airplane will be operating continuously in cold weather.

Convair recommends using dry nitrogen, rather than compressed air, for inflating struts and truck positioners. This is especially applicable in cold weather because of the possibility of condensation of water from nominally dry air.

Tires should be inflated to load standards, regardless of possible rise in pressure under warmer conditions. Underinflation quickly causes overheating that would result in more tire damage and more possibility of blowout than would a slight amount of overinflation.

If a tire is frozen to the ground, it should be thawed with warm air or water; and, of course, moved before refreezing.

It is easy to exceed nose gear towing load limits in snow or slush. If the airplane must be towed in deep snow, it should be pulled by cables attached to the main landing gear lugs.

AIR CONDITIONING:

Good operating practice, as well as passenger and crew comfort, requires that temperatures in the cabin and other normally heated areas of the airplane be stabilized at a relatively comfortable level before passenger loading.

For cabin heating on the ground, most versions of the Convair jet airliners have a connection for using conditioned air supplied by a ground cart. The airplane systems are also designed for ground use with external power, supplied by electrical or compressed-air sources depending on the type of system in the airplane.

In electrically-operated air conditioning systems, ground heating is provided by electric duct heaters, with a total of seven elements. The number of elements energized is automatically regulated by cabin temperature controls. In bleed-air-powered systems, the turbocompressors provide heating on the ground as in flight, by recirculating a certain proportion of the airplane turbocompressor output.

WATER AND WASTE:

It is better not to refill water tank and waste tanks until the cabin is warmed. Then the pressure pump can be turned on and the lines checked, to be sure they are clear. Water probably will not freeze in the main water tank itself unless the airplane has to sit unheated for several hours.

ELECTRICAL:

The battery should require no special care beyond the routine checks for charge.

The ice detector probes in the engine inlets will not be affected by ice formation; however, contamination by other fluids during cleaning could be harmful. Therefore they should be protected by slip-on covers when using solvents or anti-ice fluids in the area.

OPERATING — GENERAL

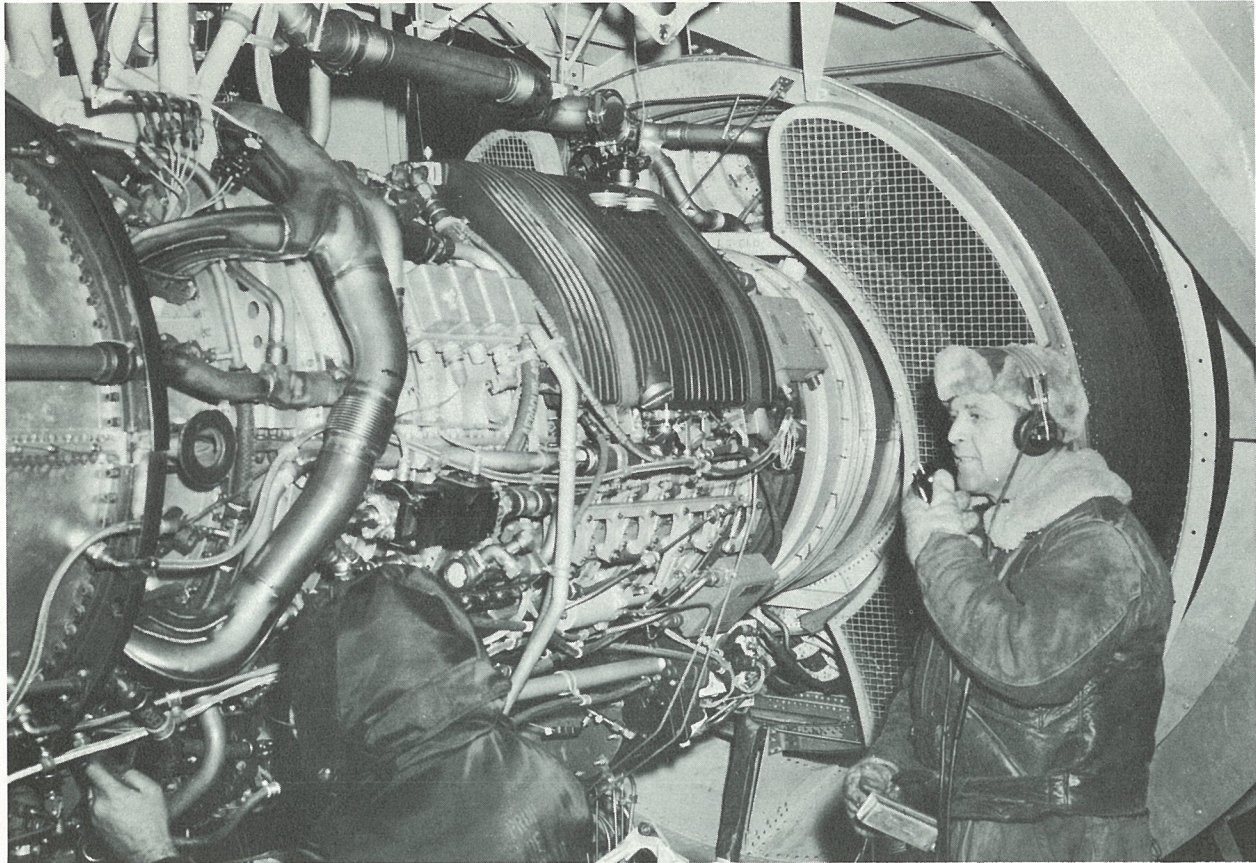
Whenever jet engines are started on snow-covered fields, the exhaust will melt a path through it, extending quite a way back if engines are run up. This may add run-way complications if the water refreezes as glare ice.

Runways are likely to slough or crumble somewhat in winter. The jet blast may pick up gravel or even a piece of pavement and hurl it some distance, causing damage to buildings or other aircraft. The possibility of ingestion of debris, including sand or cinders, into the engine always exists. It is harder to keep debris off snow-covered areas, but it is particularly important to do so.

On a takeoff run in water or slush, the drag of the landing gear wheels is relatively greater at high speeds. At 120 to 150 knots, there may be a feeling of heavy drag and the takeoff distance may be lengthened accordingly.

In-flight anti-icing systems of the "880" have been thoroughly checked out, in component tests in laboratories and at Mt. Washington, N.H., and in actual "880" operation in storm fronts. Last spring an "880" spent several days in Alaska and the Northwest, hunting out the worst available flight conditions, where ice could be built up in engine inlets and on tail leading edges and windshields. The "880" anti-icing and de-icing systems demonstrated their ability to keep the aircraft clear of ice during continuous icing conditions.

When it comes to winter ground care, however, experience is limited. The "880" has not yet been in daily airline service in northern areas in midwinter. As Convair's jet airliners finish out their first year of service, Convair field representatives will be on the alert for any special cold-weather characteristics or requirements. Operators will be advised of significant findings as experience is accumulated.



Convair 600 GE CJ805-23 engine in special test rig undergoes anti-icing tests in Minnesota winter.

Pod Inlet Anti-Icing Convair 600

Basic design and principal elements of the "600" pod anti-ice system were proved out in the "880" test program when a built-up pod and engine were taken to Mt Washington for test runs. Mt Washington, while maintaining without much argument its claim to the "world's worst weather," has certain disadvantages for a test project; the weather is so extraordinarily bad that personnel and equipment may be isolated for days at a time.

When it came time to put the "600" installation through equivalent tests, it was decided to conduct them at Hopkins, Minnesota, near Minneapolis, where Research, Inc., has test facilities available. Minnesota usually has no trouble supplying below-freezing temperatures during the winter, and, if anything breaks down, parts can be obtained and repairs made without major delays.

The test rig was fabricated at the Convair plant in San Diego, California. It consisted of an intake duct with a bellmouth, a frame and housing for the engine, and an ejector duct nearly 30 feet long. Function of the ejector duct was to furnish airflow over the outside of the pod and to increase intake velocities, simulating flight conditions as closely as possible.

The negative pressure caused more air to flow through the bellmouth, which resulted in increased velocities. At idle speed (60% rpm) the velocity in the bellmouth was equivalent to an airspeed of 85 knots; at climb setting (97% rpm), velocity and pressure were equivalent to approximately 300 knots at 5000 to 6000 feet pressure altitude.

It took approximately six weeks to put the test equipment together, ship it to Minnesota on flatcars, and set it up with the proper instrumentation. The equipment included vibration pickups, temperature recorders, complete engine and anti-ice control panels, and a large manometer board with multiple mercury columns for indicating pressures at numerous pickup points.

Once in readiness, the tests were run rapidly whenever the weather wasn't too uncooperatively mild. To supply icing, test engineers created a lattice of water pipes, placed in front of the bellmouth. Special nozzles mixed compressed air and water and sprayed it into the airstream, at whatever rate was desired. Water droplet sizes of 10 to 25 microns were obtained. Rate of flow varied from half a gallon to five and six gallons per minute.

Many runs were made at "ideal" icing temperatures, from 15° to 25°F, and at temperatures down to almost zero. It was established that the inlet surfaces would be kept evaporative-dry at all climb, cruise, and hold engine control settings, under maximum continuous icing conditions. With engine at idle, the surfaces would still be running wet.

Because of the short time involved for descent through an icing cloud, runback and refreeze did not pose a serious problem. There was no overheat of the surfaces at any setting.

The only changes recommended were a few minor corrections in bleed air flow volume and bracketry. Convair continued the test runs for some days after the FAA representatives left. By the time the exhaustive program ended, the tests had proved the original design predictions to be accurate, and the system able to handle icing conditions equal to the maximum possible in flight.

In icing conditions, ice can build up rapidly on engine nose cowl and compressor inlet components. All versions of the General Electric CJ805 engines that power Convair 880 and 600 aircraft use 17th stage compressor bleed air to heat the front frame struts, nose fairing, and inlet guide vanes. In the "600" aft fan version, bleed air is also directed through outlet guide vanes.

Engine front frame and guide vane anti-ice systems are part of the engine assembly, developed by General Electric and tested by them in the subzero blizzards at the top of Mt Washington, N.H. No less important is an anti-icing system developed by Convair for the nose cowl forward of the compressor inlet. In the

"880," there is only the leading edge of the pod and the hub fairing to be protected. In the "600," there are the forward outer ring, or common inlet; an inner compressor ring, or primary inlet; the hub fairing; the "islands" at the top and bottom between inner and outer rings; and the "splitters" that divide the large air ducts which lead back to the aft fan. All these must be protected against ice buildup, which could break loose and damage compressor or fan blades as well as interfere with the airflow.

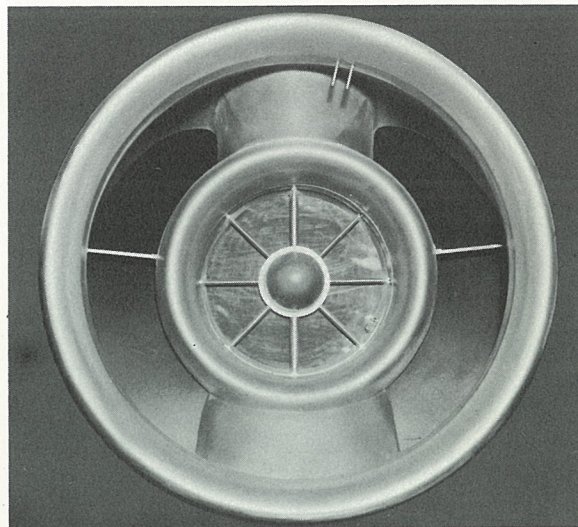
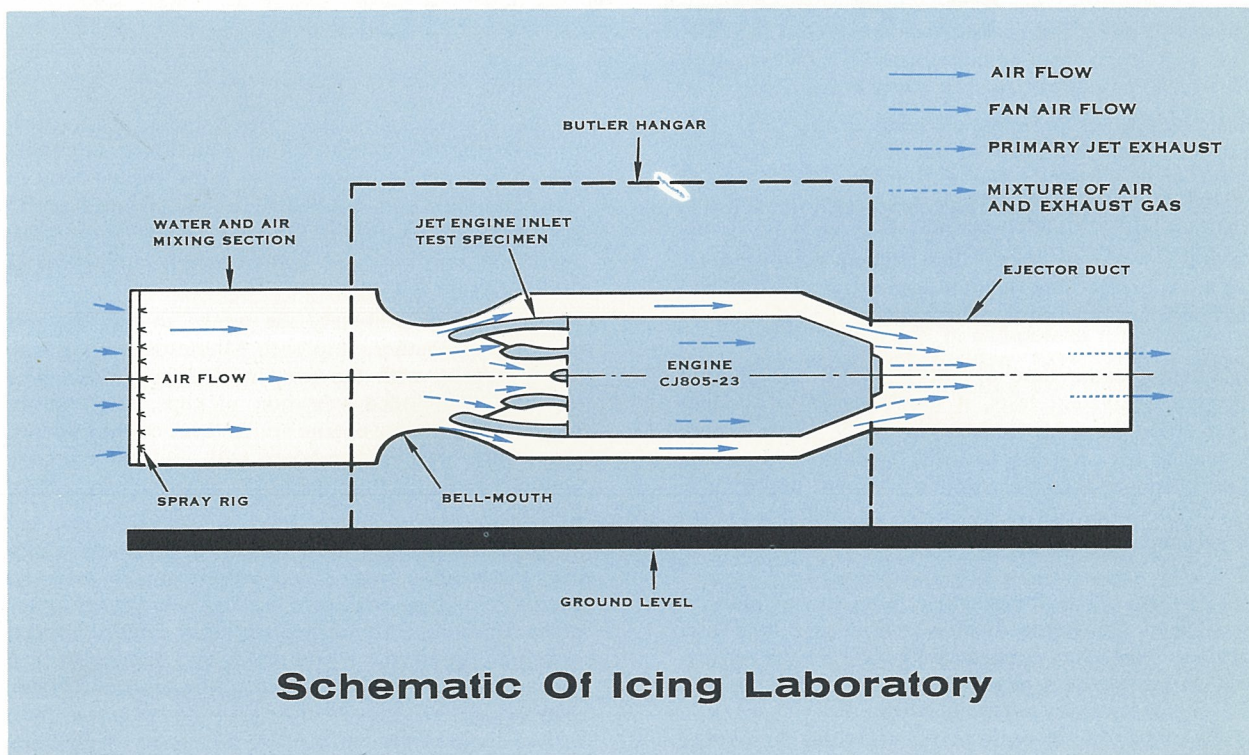
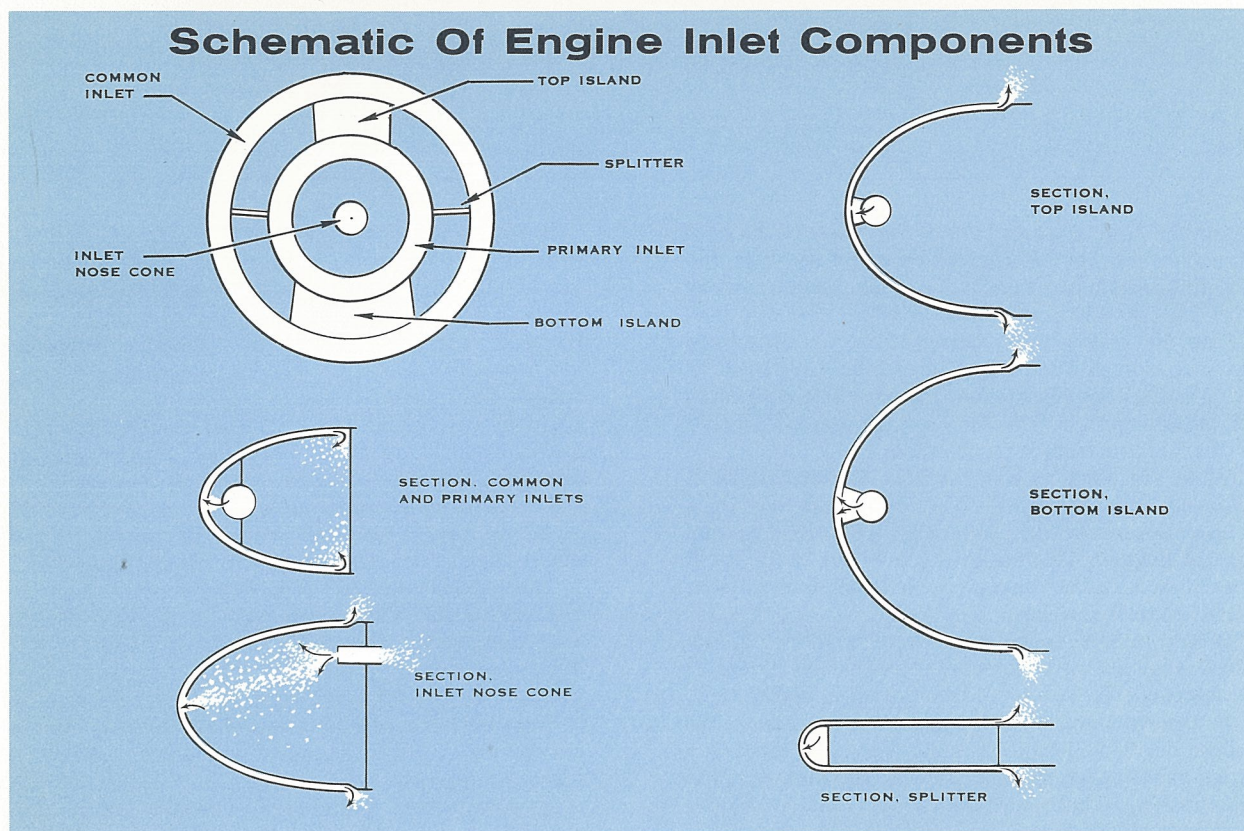


Photo shows engine inlet parts requiring anti-icing. Ice detector probes are at top.



Schematic Of Icing Laboratory



Inlet Anti-Ice System

The pod common inlet and primary inlet leading edge assemblies each consist of .090 alclad with chemically-milled passages, .040 deep and 1-3/4 to 2-1/2 inches wide, separated by 7/16-inch lands; inner skins of .025 alclad, spotwelded to the lands of the outer skin; and a "piccolo" tube of .020 titanium, perforated along the forward side with 1/16-inch holes that direct bleed air flow at the leading edges.

The tubes are attached to the skin by angles that seal off the forward four inches of the leading edges into D-ducts. Hot air is directed at the foremost point of the leading edge, and flows back through the milled passages to heat approximately the forward six inches of the inlets. Aft of the passages, the air is discharged into the engine airstream through 3/16-inch holes, drilled through the skins. There are four groupings of discharge hole patterns in the inner cowl, six in the common inlet cowl.

Splitter leading edges have double .020 titanium skins with spacers in between. Both skins are continuous around the leading edge; the inner skin is drilled to allow passage of hot air to the inner surface of the outer skin. The interior of the leading edge is a D-duct, which is fed with bleed air from a tube teed into the anti-ice ducting. The hot air flows back between the skins and vents five inches aft of the leading edge.

In the islands, half-inch piccolo tubes run down the centerlines. Hot air flows back between inner and

outer skins through transverse chemically-milled channels, discharging at the island aft edges.

Airflow to the components is metered by the small holes in the piccolo tubes; the pressure is regulated by an anti-ice control valve set at a 13 ± 2 psig downstream pressure. Piccolo tubes are of titanium; islands and cowl leading edges are of aluminum alloy. For the skin, a temperature of approximately 300°F should not be exceeded. During flight, the airflow around the heated components will keep the temperature within a safe margin, but for ground run-ups, where there is no forward motion, overheat must be guarded against. A temperature sensor in the outer ring will shut off the hot airflow to the inlet before a dangerous temperature is reached.

In both "880" and "600" aircraft, a double probe ice detector, in the common inlet, signals when ice is encountered. Each probe has small holes in the forward face; one is constantly heated by an electrical element. When ice forms on the unheated probe, ram air pressure differential between the two probes actuates an anti-ice switch. In the "880," the anti-ice switch automatically actuates the major anti-ice systems — engine and pod, windshield, wing, and empennage. In the "600," by customer request, the anti-ice systems are manually operated at the pilots' discretion. The probe switch illuminates an ice warning light on the pilot's overhead panel.

Flight Control Windlock During Ground Check

About the time he straps himself into his seat, the pilot of a Convair 880, like most other pilots since the Wright brothers first flew, will probably automatically work his flight controls a time or two, to be sure they feel normal and are not binding. If there is wind from any direction except straight ahead, he can expect to feel it in the controls, the more so because the surfaces are all tab-operated and the leverage exerted directly on the main surfaces is much reduced.

What the pilot may not expect to find is that a relatively small tail wind can sharply limit the travel, or even appear to jam completely, a perfectly normal control linkage. This might occur in an "880," as it does in some other aircraft with large manually-operated control surfaces.

Either rudder or elevators may be affected; the ailerons are less susceptible. A brief analysis of rudder mechanisms will serve to show how it happens.

In a normal ground check from the flight deck, the rudder pedals will first move the flight tabs through a range of 42° , 21° to either side of streamline. If the pilot wishes, he can move the rudder itself. Tab travel limit is established by a stop, contacted by the rudder hinge line bellcrank. The stop is attached to rudder structure; therefore any further pressure on the pedal will be fed through the stop to the rudder main surface. In still air, normal pilot foot pressure is sufficient to move the rudder through some portion of its travel.

Moment arms of the bellcrank linkages are engineered primarily to move the tabs. Moment arm at the rudder hinge line bellcrank, on the pedal side, is approximately $3\frac{1}{2}$ inches maximum. Transmitted to the flight tab, this moment will move the tab against almost any wind; but when the force is applied to the rudder directly, the moment arm is reduced by partial rotation of the bellcrank. Also, rudder surface is ten times that of the tab, and aerodynamic forces are multiplied accordingly.

Let us say that a wind blows the rudder to the right, as in the illustration. It will probably deflect only 14° , at which point it contacts a spring in the gust damper. The centering spring tends to hold the hinge line bellcrank — and the pedals — at neutral or streamline position; therefore the flight tab will "anti-servo" — deflect on toward the right another 14° , leaving the pedals at streamline position.

Now, should the pilot push down on the left pedal, he will without difficulty move the flight tab to the right, in the normal direction for left rudder, to the 21° limit of tab travel — only 7° more. To push the pedal down farther, he would have to move the rudder back to streamline by leverage on the tab stop. Since the wind can easily exert enough force on the large surface to counteract the pilot's foot pressure, his pedal travel will appear limited to 7° from streamline.

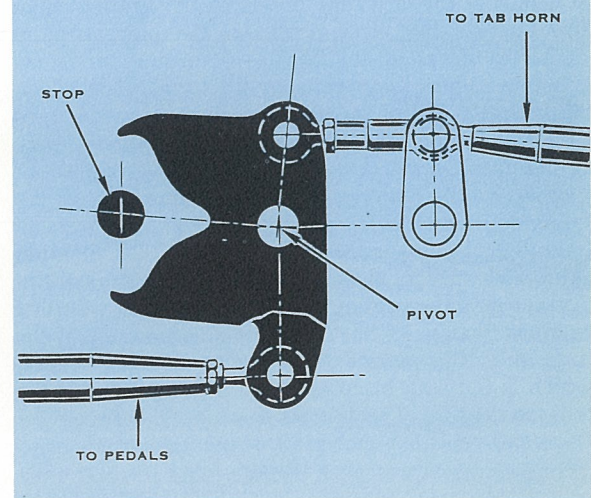
But when he pushes the right pedal, he will be able to move the tab toward the left against the wind, first the 14° to streamline, then on left to 21° full deflection — 35° altogether. He still has 42° of effective travel, 7° left and 35° right, but his center reference has been shifted; and he will not be able to move the rudder itself at all.

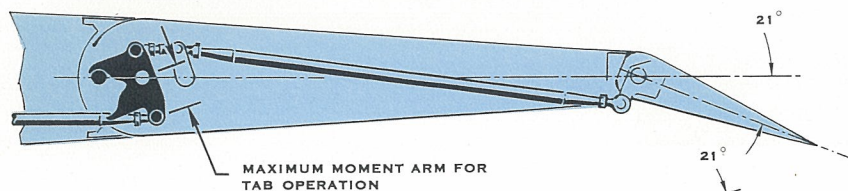
In the case of elevators, cockpit control may similarly appear normal or more than normal in one direction, but impossible in the other. The elevators are not directly interconnected. If one elevator should be blown up and the other down, the control column might appear almost solidly jammed in one position.

The aileron system is designed purposely to provide a ground check. The pilot moves the control wheel to a certain travel, depending on the position of the ailerons, and then the tab bellcrank at the aileron hinge contacts a "ground check bar" and drives the aileron to full deflection, visible to the pilot. Leverage on the check bar is enough that only a very strong wind could lock the ailerons.

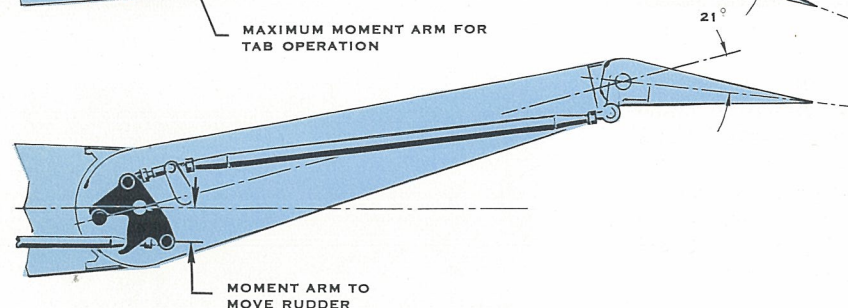
As long as the "wind-lock" effect is known and anticipated, it should cause little inconvenience. When it happens, the airplane should always be turned into the wind for a recheck before takeoff. If then the controls do not move normally, or if any control does not operate normally in still air, takeoff should be held up until the cause is found and eliminated.

Detail Of Bellcrank

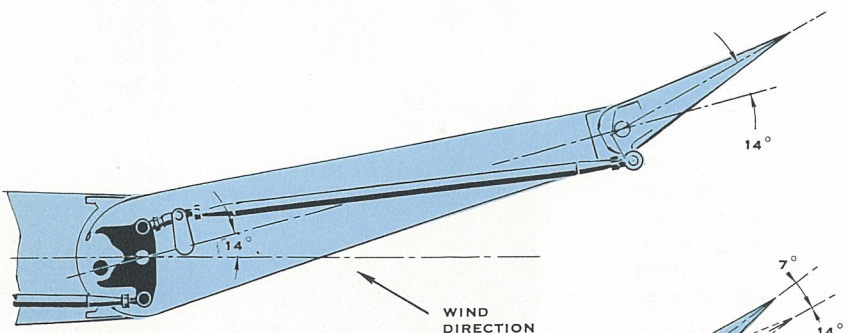




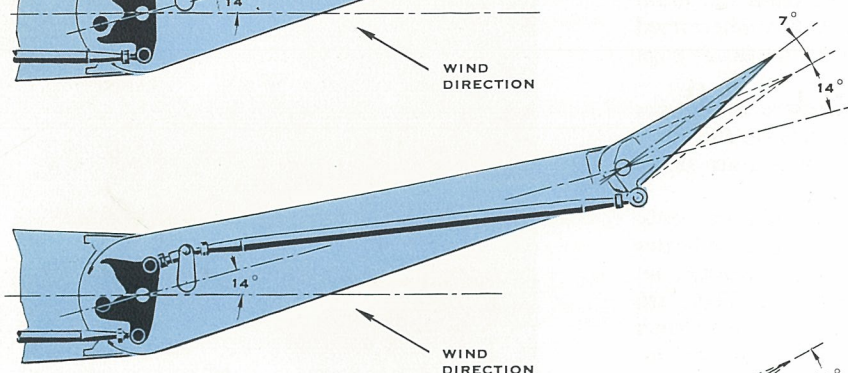
Normal check, right rudder applied, tab deflected until bellcrank strikes stop.



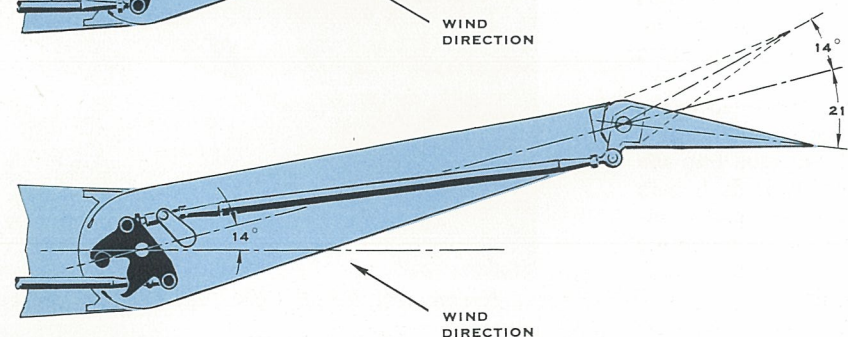
Bellcrank force on stop then deflects rudder.



When rudder is blown by wind, bellcrank may remain at streamline position.



Left rudder applied, wind force holds rudder hard right.



Right rudder applied, pedals act normally, rudder deflected to right.

Schematic - Rudder And Tab Linkage During Ground Check

Drip Sticks

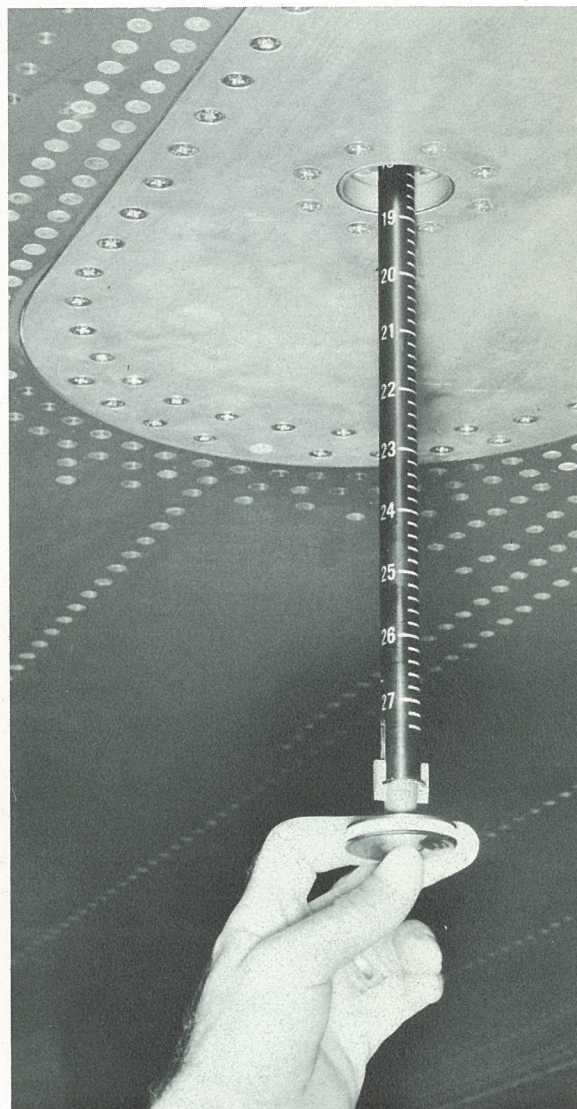
Mechanical measurement of fuel amount in the Convair 880/600 is accomplished by retractable liquid sight fuel quantity gauges called "drip sticks." These indicators, installed flush with the underside of the wing at the bottom of the integral wing fuel tanks, are slender hollow measuring tubes that extend up into each tank through sealed flanges. The tubes are calibrated in inches or pounds, depending on customer requirements.

To read the drip stick, the tube is first unlocked from the mounting flange by pressing upward on the base of the tube and turning it slightly until the base drops below the flush position. A drain hole is opened at the bottom of the tube by depressing a button at the center of the base. The tube is drawn down through the sealed flange until fuel begins to drip from the drain hole. The tube is then slowly pushed up until the dripping stops, and then is carefully lowered again, stopping at the instant fuel streams from the drain hole. The amount of fuel in each tank is determined by reading the tube calibrations against the inside edge of the mounting flange.

Care must be exercised in reading the drip sticks because the calibrations are "backwards" to the usual measuring sticks; that is, the high numbers are at the bottom of the scale.

When it is necessary to draw the tube out only a short distance to take a measurement, it indicates a tank that is nearly full; whereas, the tube drawn all the way out indicates an almost empty tank. There are approximately 2.9 inches of unmeasured fuel in each tank; the drip stick mounting extends this distance into the fuel tank, preventing the measuring tube from bottoming to the tank floor.

When not in use, the drip stick is contained in the tank and held in the retracted position by the latching mechanism that locks the base of the tube into the mounting flange. The latched assembly is flush with the skin of the wing. A funnel-shaped receptacle, attached to the roof of the tank opposite the mounting flange, fits over the top of the contained tube, thus securing it under fuel sloshing conditions.



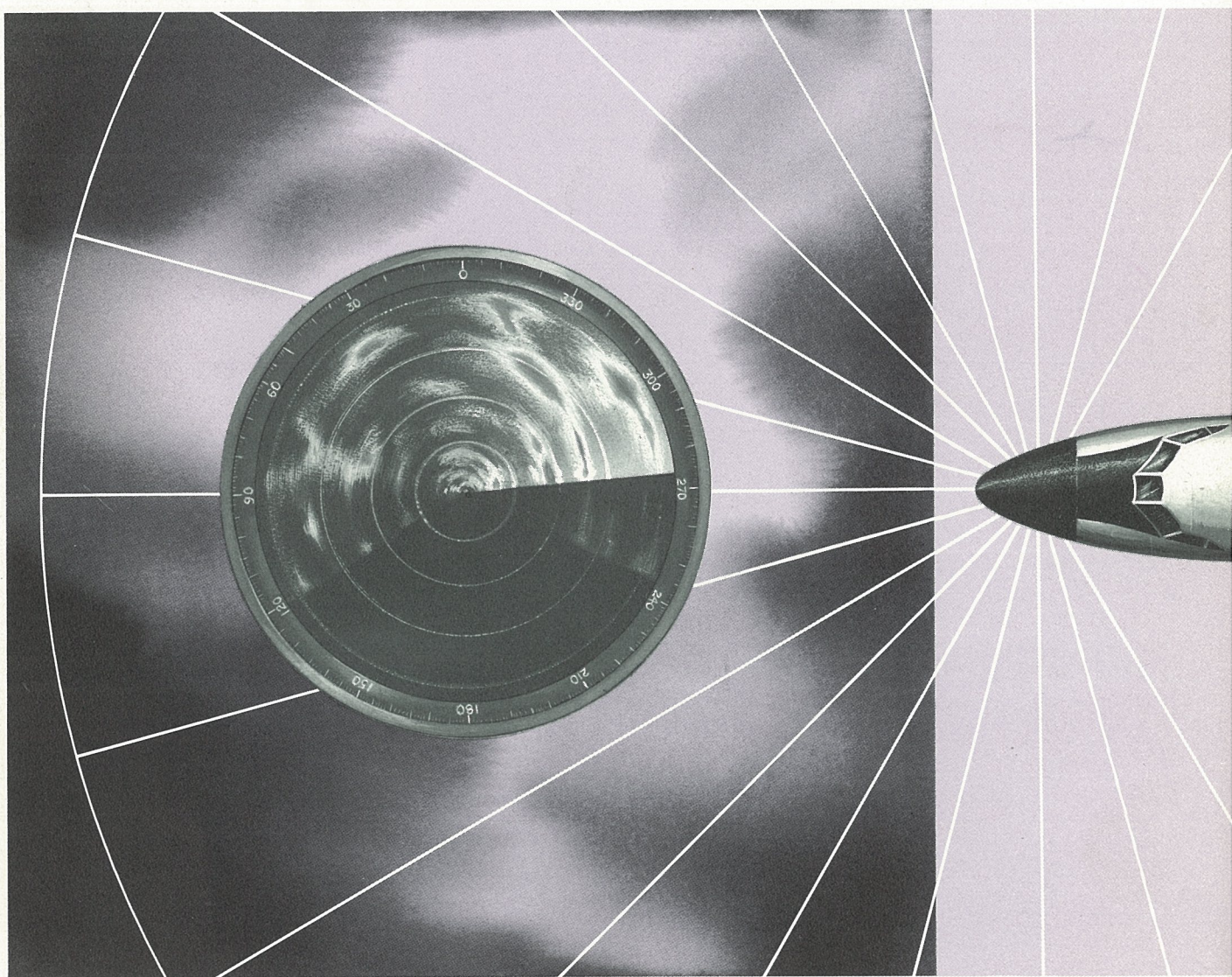
Retractable liquid sight fuel quantity gauge.

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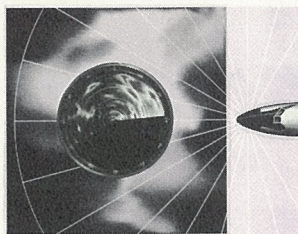
Convair Traveler



In this Issue: Weather Radar in the Convair 880/600

VOLUME XII NUMBER 7 NOVEMBER 1960

Convair *Traveler*



In this Issue: Weather Radar in the Convair 880/600

OUR COVER

Piercing a troubled sky with searching eyes, weather radar presents a cockpit display of storms and turbulence ahead. This feature permits Convair jet airliners to be directed around storm centers for safer, more comfortable flights.

*Cover design by Norm Harrington;
Illustration by Tony Adams.*

Convair *Traveler*

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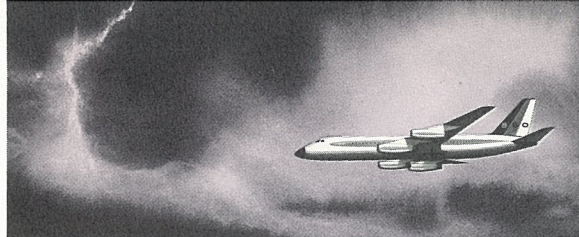
BACK COVER

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ENGINE BUILDUP LINE
Sam Urshan

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Weather Radar in the Convair 880/600

RADAR, which stands for RADio Detection And Ranging, was developed during World War II for military use. Placed aboard service aircraft, this new device, with its ability to "see in the dark," proved to be much more versatile than its designers had anticipated. Initially designed to be operated as a navigational and bombing aid, radar scored a hit by becoming adaptable to a variety of other uses including weather surveillance. Radar operators quickly discovered that, with a little practice, they could identify storms on their radar scopes and steer clear of such disturbances.

Proving its worth during many thousands of flight hours in the hands of military fliers, radar was ready to be adapted to civilian use at the close of the war. The system, designed as weather radar, was installed in commercial airliners for the primary purpose of indicating storms and atmospheric disturbances. Commercial radar enables pilots and navigators to pick out smooth paths through storm fronts and turbulent areas.

The Convair 880/600 jet airliners are equipped with the most modern weather radar systems available. With the experience gained through the installation of radar sets in the Convair-Liner 440, Convair was able to design the radar installation in the 880/600 for ease of access, serviceability, and optimum results. Particular radar systems are installed on the 880/600 according to customer requirements.

Radar is based on the principle that high frequency radio waves, like light, will reflect from an object

caught in its path. The radar signals are transmitted as high power pulses that reach the object (target) in a straight line, after which part of the signals are reflected back to the transmitting source. These reflected signals are converted into visual indications and are viewed in the cockpit on a cathode-ray tube indicator, or scope.

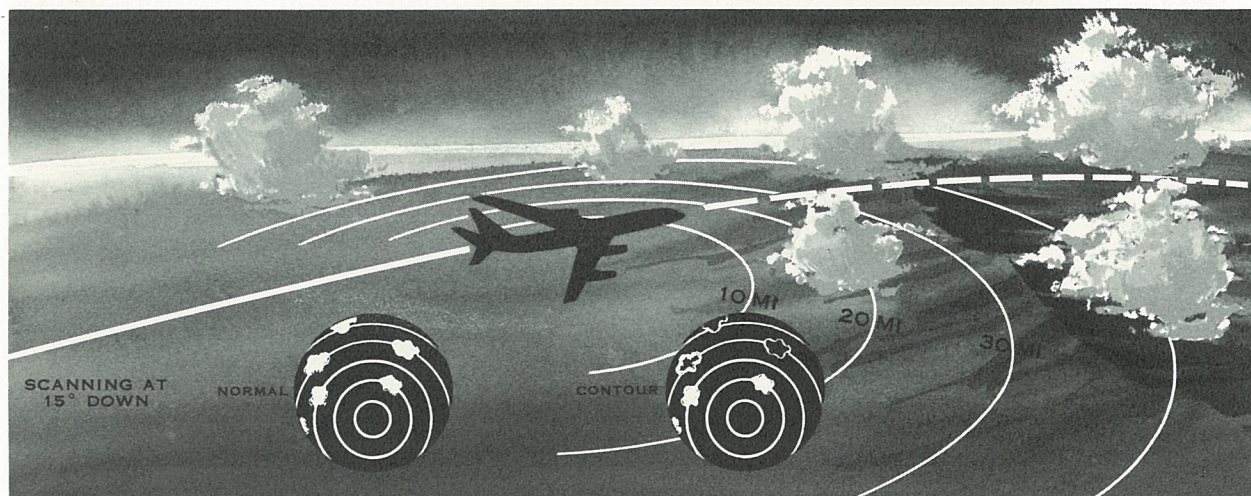
The length of time it takes the radar signals to reach the target and return is accurately measured electronically to furnish range. Azimuth information is obtained through the action of the radar antenna which rotates through 360° — transmitting and receiving signals in a narrow beam, comparable to that of a spotlight.

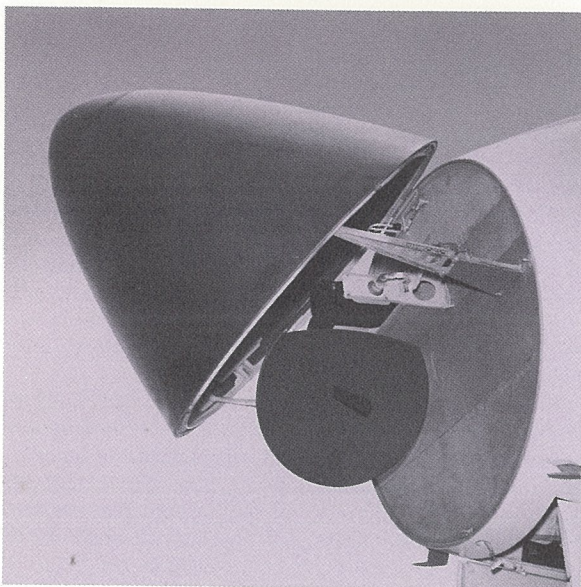
Continuing post-war development has perfected a feature known as iso-echo contours, a refined scope presentation that enables a pilot to determine quickly and accurately the position, intensity, and extent of storm cells. The reliability of this system permits the pilot to pick a route through a storm area within four miles of its turbulent centers, thereby minimizing detours and delays.

As the intensity of the weather radar return signal depends on the concentration of water particles in the path of its beam, and the turbulence of a storm is proportional to its rainfall gradient, usual conditions indicate that the brighter the return, the worse the storm. But, during some conditions, the face of the radar scope will show an indistinguishable return, as when radar-reflecting particles are prevalent in the area of sweep. In such cases, the iso-echo contour feature of the radar system is brought into play.

This iso-echo contour feature of the weather radar system permits positive identification of storm areas and accurate positioning of the turbulent cells, regardless of the contrast nature of the picture. When the rainfall gradient reaches a certain level, the screen goes black in those areas. The resultant picture shows characteristic black "holes" ringed by light areas. By avoiding the black areas which indicate high turbulence, the pilot can continue on course along a relatively smooth flight path.

Iso-echo contour feature of 880/600 weather radar presents smooth flight path between storm centers.





Radar antenna, rotating 360° at 15 rpm during operation, is located in plastic radome nose.

This feature has proved to be economically advantageous because it makes possible the prevention of long and costly detours around storm centers, and permits much smoother flights for passengers.

Weather radar, as installed in the Convair 880/600 jet airliners, is designed to offer the additional feature of terrain mapping. With the antenna beamed slightly downward, this navigational aid makes possible the identification of coastlines, rivers, cities, and other prominent landmarks.

Another feature of the versatile radar system is its ability to indicate absolute altitude above the ground

by use of the altitude circle. A small amount of radiated energy constantly escapes from the normal pattern of the radar beam and strikes the ground vertically. The reflected target appears on the radar scope as a circle, caused by the rotation of the antenna. With the range marker set on the 20-mile range, absolute altitude is determined by estimating the distance from the sweep center to the inside of the altitude circle.

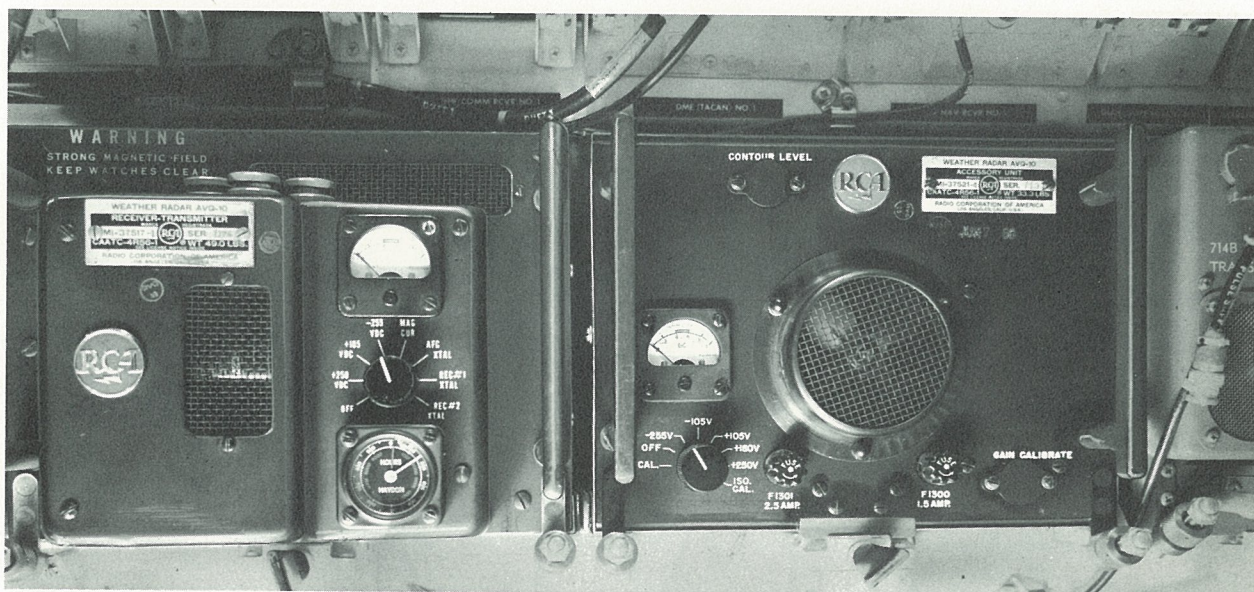
The weather radar system installed in the Convair 880/600 jet airliners is either in the C band or the X band, depending on customer requirements. The C-band equipment operates on a wavelength of 5.7 centimeters and has a frequency of 5250 to 5440 megacycles. The X band has a wavelength of 3 centimeters and represents a frequency of 9200 to 9400 megacycles.

The weather radar system consists of five units: the receiver-transmitter, the synchronizer unit, the antenna, the indicator, and the control panel.

The receiver-transmitter unit is located in the radio compartment beneath the flight deck in the left-hand equipment rack. It contains the basic electronic circuitry (RF and IF) for the transmission of signals to the antenna and for receiving the signals reflected back to the antenna. These reflections are translated by the receiver into the visual indications — light areas of varying intensity — displayed on the cathode-ray tube indicator.

The synchronizer unit contains the power supply, the basic timing circuitry, and the servo amplifiers, which amplify the voltages used to synchronize the indicator sweep traces with the rotation of the antenna. It also provides voltages of proper amplitude and phase for horizontal stabilization of the antenna. The synchronizer unit, also located in the radio equip-

Receiver-transmitter at left and synchronizer unit at right are two of the five units of radar system.



ment compartment, is installed at the right side of the receiver-transmitter unit.

The radar antenna radiates radar energy and receives the portion that is reflected back from the target. It is of parabolic "dish" shape and rotates continuously through 360 degrees at a rate of 15 revolutions per minute. The antenna assembly provides vertical tilt and stabilization of the antenna against roll and pitch of the aircraft.

The radar antenna is located within the radome in the nose of the 880/600. The radome is hinged at the top and can be swung open for access to the antenna assembly. The radome is held in the open position by hold-open supports on each side.

The indicator, known as the Plan Position Indicator (PPI), is basically a cathode-ray tube that converts the reflected radar energy received by the antenna into the visual indications of light and dark areas visible on the face of the tube. Indicator adjustments control the brightness of the indicator sweep to bring out the best "picture" on the tube, and control the lighting of the indicator panel. Some indicators have cursor lines, scribed on the face, that may be rotated for an azimuth fix on a target. CONTOUR and RANGE controls are also mounted on some indicators.

The indicator is located just below the engine instrument panel, on the pilot's side, directly in front of the control pedestal.

The radar control panel contains all of the system controls with the exception of those on the indicator. There is the OFF-STANDBY-ON switch for turning on the set, the GAIN control that adjusts the sensitivity of the receiver, and the TILT control that moves the antenna reflector up or down to direct the radiated beam to the desired angle. The RANGE

control, either on the indicator or on the panel, selects the desired range markers (20, 50, 150 nautical miles) and adjusts the light intensity of the marker rings. The CONTOUR switch on the panel or on the indicator activates the iso-echo contour function of the set for more accurate determination of storm cells.

The radar control panel is located on the panel just below the engine instrument panel. It is positioned directly below the indicator.

Microwave-absorbing material is installed on the bulkhead behind the radar antenna to protect radar receiver circuitry.

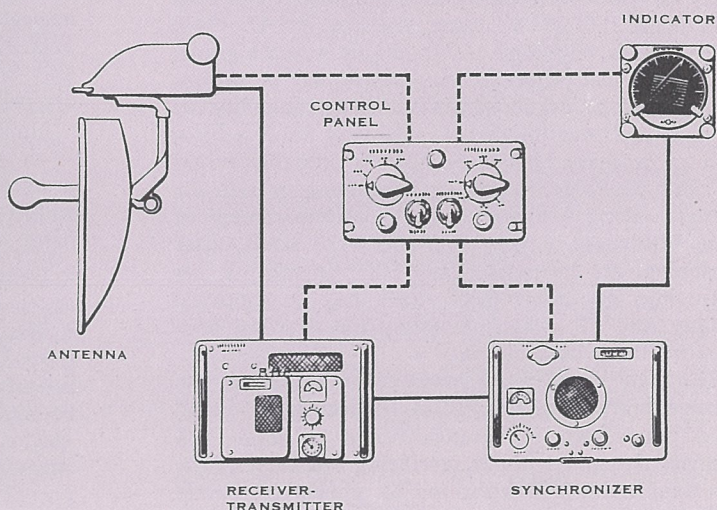
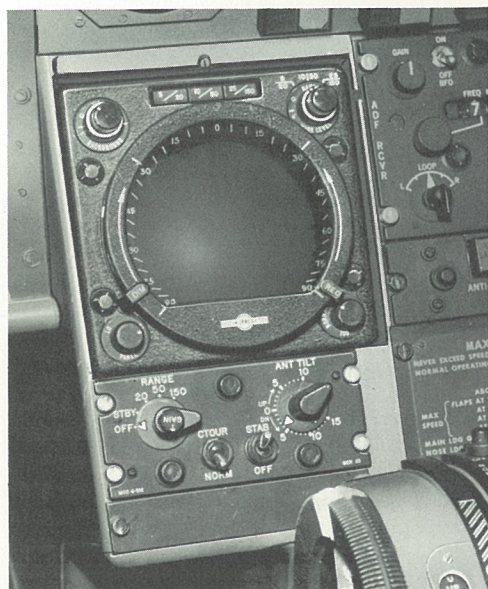
To eliminate the possibility of injury to personnel, no one should be exposed to a direct radar beam where the power density is above the maximum allowable of 0.01 watt per square centimeter. No person should be exposed to unattenuated radar beams within 75 feet of a radiating antenna.

In field testing, the radar beam should be directed as high above the horizontal as is practical. Before operating radar equipment, the affected area should be posted with signs and flasher lights, and should be supervised to preclude the possibility of exposure to the radar beam.

To prevent possible damage to the radar equipment, the set should not be operated while the aircraft is in an enclosure, or with the antenna directed toward large metal objects close at hand. The system should never be operated during fueling operations or in proximity to fuel containers.

Unshielded electric primer caps, squibs, other explosives, and even photo flash bulbs are capable of being detonated by microwaves, and should not be stored or transported within the area around an energized radar set.

Weather radar indicator (scope) and control panel are at right of pilot, below engine instrument panel.



Landing Gear Steels-Convair 880

A Convair 880 landing gear is as finely made and as precisely put together, scale for scale, as any watch. It must be. Comparatively light in weight, a main gear must bear a load of many tons, sometimes at speeds approaching 200 mph. It must handle this load during landing impact and under heavy braking, with additional margin for emergencies.

The strength to withstand such stresses, in a size and weight compatible with airplane use, is not bought cheaply, either in design or in materials. It took thousands of hours to define basic design requirements and more thousands to work out the mechanisms to meet the specifications. Where strength and fatigue resistance are needed, only the strongest toughest steels available today meet the requirements.

Many landing gear parts are still made of aluminum, or of steel processed to what is coming to be considered a low-heat-treat range — 180 ksi (180,000 pounds per square inch) or less tensile strength. But parts carrying major lateral and longitudinal stresses — nose gear side braces and lower drag brace, main gear drag braces and torque arms, are 220 to 240 ksi steels. So also are the nose gear strut cylinder and piston, nose and main gear axles, and many of the pins and bolts.

Two major assemblies, the main gear oleo strut and the axle beam, are of still higher heat-treat level. Nine-tenths of the airplane weight rests on the main gears. More specifically, it is concentrated at the struts; with the airplane fully loaded, more than 40 tons rest on each strut, which in turn rests on the approximate center of a single longitudinal tubular beam (the "bogie beam"), at the ends of which are the axles. To bear this concentrated load, strut cylinders, pistons, and the bogie beams are of chrome-molybdenum-nickel steel, heat-treated to 260 to 280 ksi. A few pins and bolts in both main and nose gears are of this high-heat-treat level.

The 220/240-ksi steels are AMS 6407 (a low alloy steel) or AMS 6427 (SAE 4330 modified). For heat treat to the 260/280-ksi range, the steel is SAE 4340, an electric-furnace fine-grain steel of aircraft grade.

For practical purposes, these steels may be said to be processed to just about their ultimate capability for strength and toughness. They are very hard; a blow with an ordinary ball peen hammer probably would not dent the bogie beam. The hardness goes with the strength, along with a necessary accompaniment of some brittleness. AMS 6407 and 6427 steels, after hardening, are heated to only 500° to 600° F for tempering; the 260/280-ksi steels may be tempered at only 400° F — approximately the drawing temperature for a cold chisel.

Although the alloy content increases toughness and "hardenability" (capacity for hardening to depth when quenched), it is not possible to obtain the requisite strength without sacrificing ductility. High-heat-treat steels will withstand an almost incredible static load, and even severe impact without failure — but not necessarily without damage.

This fact is being recognized by airlines operating heavy jet transports. In the test program and in service to date, the "880" landing gear has had a very good record. This is because of the background of structural analysis during design; every pin and bolt, every juncture where parts are mated, was subjected to meticulous stress analysis and the detail design tailored to the requirement. The "880" record will continue to be good; but it is more dependent than ever before on careful maintenance and inspection.

An example is a main gear truck found to have a slight dent in the bogie beam, apparently caused by jacking the front axle too high in an effort to get a jack under the center jack point with both rear tires flat. The excessive truck angle caused the yoke at the bottom of the strut piston to contact the beam. Thorough inspection showed no external crack, nor any sign of internal damage that could be seen without removing the beam, and the airplane was flown some days without mishap. But, when the beam was removed for better inspection, it turned out to have an internal surface crack under the dent that, sooner or later, might have caused failure.

In Convair testing, it has been found that damage to hard steel may occur from impact or high local stress concentrations that leave no visible dent. There is only one safe rule to follow: whenever there is any visible indication of high stress or impact, or whenever it is known that a gear part has been subjected to heavy impact or localized stress, the part, whatever its appearance, should be removed and thoroughly inspected by all the methods at hand.

Penetrant inspection is useful for bare or chrome plated parts, particularly if the part can be inspected under stress. But, dye penetrant inspection is not enough today. A cadmium coating is ductile, and may remain unbroken even though the surface of the steel has sustained fracture. X-ray is useful chiefly to verify findings from other methods. Only magnetic particle inspection, with both longitudinal and transverse polarization, and ultrasonic inspection — and preferably both — can put the final OK on steel of such critical quality.

High-heat-treat makes steels more notch sensitive — more likely to develop cracks from scratches, nicks, or abrasions, even though not caused by impact. When within relief limits, such marks should be filed out by hand, and the area shotpeened.

Overhaul practices are equally critical in importance. Most operators have become familiar with baking and shot-peening in reworking landing gear parts. The extent to which both processes are required, however, is unprecedented. High-heat-treat steels, for example, must be baked at 280° to 400°F for 8 hours before any rework; for another 8 hours after plate stripping; and for 8 hours again after machining or grinding before plating. Within an hour after plating with either chrome or cadmium, they must be baked 23 hours at 280° to 400° for embrittlement relief. If

retempered and not replaced during rework, they require a 24-hour bake at 250° for austenite stabilization as the last thermal treatment.

In brief explanation of the reasons for these process steps, the low-temperature baking for long periods serves to relieve minor stresses built up by loading, machining, or heat treat, and also to remove hydrogen. Hydrogen embrittlement, a phenomenon to which much attention has been devoted since heat treats were extended to the current ranges, results from introduction of hydrogen into the steel, usually by reaction with acids. Peening with small shot sets up surface compression stresses that add materially to fatigue life. Metallurgists are not in entire agreement on just why hydrogen dissolves into and embrittles steel under certain circumstances, or why peening helps before chrome plating, but the effects are well established empirically.

Because of hydrogen embrittlement, the acid stripping of plate, and the pickling and electrolytic cleaning of high-heat-treat steels are prohibited. Parts must be stripped by reverse current completely before replating; "plate over plate" prevents hydrogen escaping in the after-plating bake.

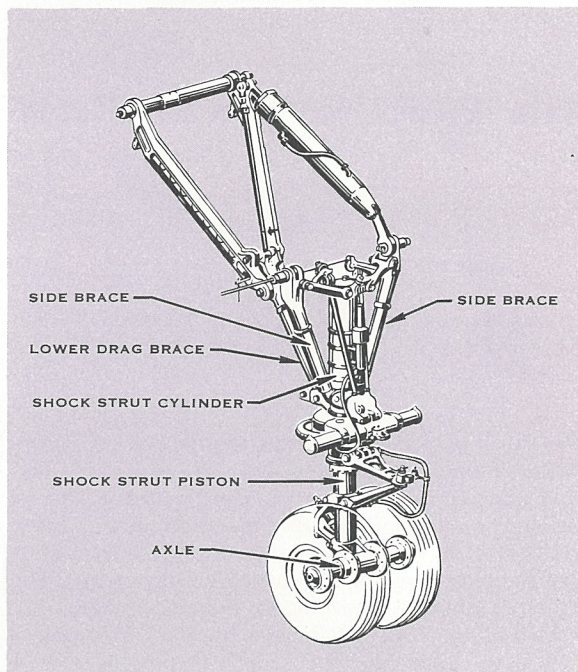
In baking, hardening, and tempering, temperature control is especially critical. It has been noted that SAE 4340 steel is tempered at 400° to 500°F. Obviously, baking temperatures higher than 400° will affect part strength; on the other hand, baking at less than approximately 375° is of limited usefulness. Decarburizing — loss of carbon from heating — is similarly of critical importance. Oven atmosphere control is necessary in any heating of 260/280-ksi steel to 700°F or more. Heating a hardened part by torch is not permissible; the heat must be rigidly controlled. Two tempers are required for all steels heat-treated to 220-ksi and above.

Grinding of hardened parts must be done with extreme care with never more than the specified amount removed per pass on outside and inside diameters. Unless the grind is only for finish of chrome plate, it must always be followed by shot-peening.

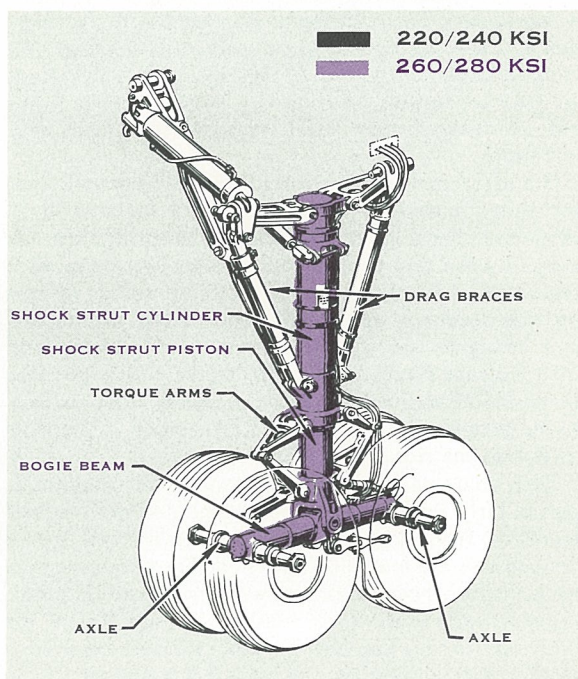
Straightening can be done after normalizing and then process-annealing the part. After hardening, the 220/240-ksi steels may be straightened under low heat; but 260/280-ksi steels can be straightened only to a limit of 1/4° overall length and at temperatures under 200°F, followed by a third 4-hour temper at 400°F.

This summary sketches, generally, most of the principal requirements and restrictions peculiar to processing high-heat-treat steels. In the "880" Overhaul Manual, a complete chapter is devoted to specific instructions on rework of steel landing gear parts. This is backed up by research conducted by Convair and Cleveland Pneumatic Tool Company, manufacturer of the landing gear, on the general characteristics of the steel and on actual landing gear parts. At Convair, extensive testing has been done on inspection methods. Parts were literally beaten to pieces with heavy sledge hammers, to find out what the gear would take, how damage begins, and how it may be detected.

The results are available in the maintenance and overhaul manuals. Some extra care in day-to-day maintenance and inspection and close adherence to the processing requirements during overhaul will pay in long service life and safe operation of Convair jet airliners.



All parts called out in nose gear (above) and main gear (below) are of steels processed to 220,000 psi, or more, tensile strength; nose steering collar and some pins are not shown.



the 880's "Beta Box"

Nearly all jet-powered aircraft require some augmentation of rudder feel. Even when the rudder is operated manually, as it is in the basic Convair 880 jet airliner, the mechanical advantage necessary to move the control surface at high airplane speeds is so great that the pilot rarely has an adequate feel of the aerodynamic loads he is placing on the empennage.

Out of the "880" flight test program has come a new development in mechanisms to provide a feedback force to the pilots' rudder pedals — new, at least, in its present application. While it might be rash to assert that the principle has never been used before, the Convair 880 "beta box" is unique in the current generation of jet transports.

In aerodynamic equations, the Greek letter "beta" is the accepted symbol for angle of sideslip. The beta box is a sideslip sensor. It programs rudder feel augmentation as a function of sideslip, rather than ram air ("Q") pressure, and thereby obtains certain piloting advantages that most systems have difficulty attaining.

Standard methods of providing feel augmentation, for either manual or powered control surfaces, have made use of springs and "Q pots." The springs provide centering feel and counteracting force, increasing with increased deflection. "Q"-pressure-operated pistons provide feedback generally proportioned to airspeed and hence to aerodynamic stress loads. Spring and "Q"-pressure forces transmitted to the pedals must be carefully tailored to furnish a reasonably close analogy to the pressures felt by the pilot of a small airplane as he moves the rudder.

One characteristic of "Q" cylinder feel systems is particularly undesirable when combined with actual feedback from the control surface in aircraft where the controls are manually operated. The contemporary jet transport, because of its swept wing and dihedral, is particularly sensitive to sideslip. If a pilot "kicks" his craft into a slip, the aerodynamic pressure on a control tab will fall because the tab is blanketed out of the

airstream by the fixed vertical stabilizer. Rudder feel diminishes; the greater the slip angle, the greater will be the drop in rudder feel. This results in an undesirable ambiguity in the pilot's sensing of rudder response.

Though Convair aerodynamicists anticipated the effect, Convair gave the conventional "Q-pot" system a thorough tryout in test aircraft. One way or another, the fall-off in rudder feel during sideslip could be compensated for, but the mechanism rapidly becomes complex and unwieldy. It was decided to return to the beta box concept, which had been worked out before the first "880" flew.

In place of a "Q" intake at the fin leading edge, sensing intakes are placed on each side just aft of the leading edge. Half-inch-diameter holes admit air to small pressure chambers, from whence it is ducted to the pressure (beta) box.

This is a triangular box, approximately 12 inches high, 20 inches long and 9 inches wide at the wide end. A paddle, hinged at the triangle apex, is sealed to the box walls by curtains, dividing the box into two pressure compartments. The paddle is attached to the rudder flight tab mechanism through a bellcrank and linkage, and swings on its hinge as the pilot moves the pedals.

A $\frac{3}{4}$ -inch-thick blade passes through an opening in the paddle, so shaped that it leaves an opening between the pressure compartments when the flight tab is centered. Unless system deflection (combined tab and rudder deflection) exceeds 4° , no pressure differential exists, and rudder feel is supplied only by the centering spring and the feedback from the flight tab. As system deflection increases beyond 4° , the opening in the paddle narrows, closing completely at 15° system deflection.

Let us say that the pilot has kicked right rudder until the empennage is slipping to the left. If deflection exceeds 4° , pressure builds on the left side of the paddle, exerting a force on the tab linkage opposing right rudder, and hence increasing feel force at the pedals. If there is much sideslip, this force will be appreciable. At the 12° sideslip angle which might occur in a maximum crosswind landing, feel augmentation would approximate 50 pounds at the pedals — almost doubling the feel force.

The beta box system, by making rudder feel responsive to sideslip rather than airspeed, leaves the controls free of heavy feel until tab deflection becomes excessive. Then, it augments the feel by an amount proportionate to the aerodynamic loads on empennage structure. At low speeds approaching stall, it supplies a warning feel proportionate to sideslip angle.

In another important rudder operating condition, flight with one or two engines inoperative, the beta box supplies a positive aid to the pilot by helping him hold a constant high angle of rudder deflection. This is an inherent characteristic of the sideslip sensing system. It has helped the "880" to retain manual rudder control without adding rudder power boosts for emergency engine-out takeoffs or enroute two-engine-out flight.

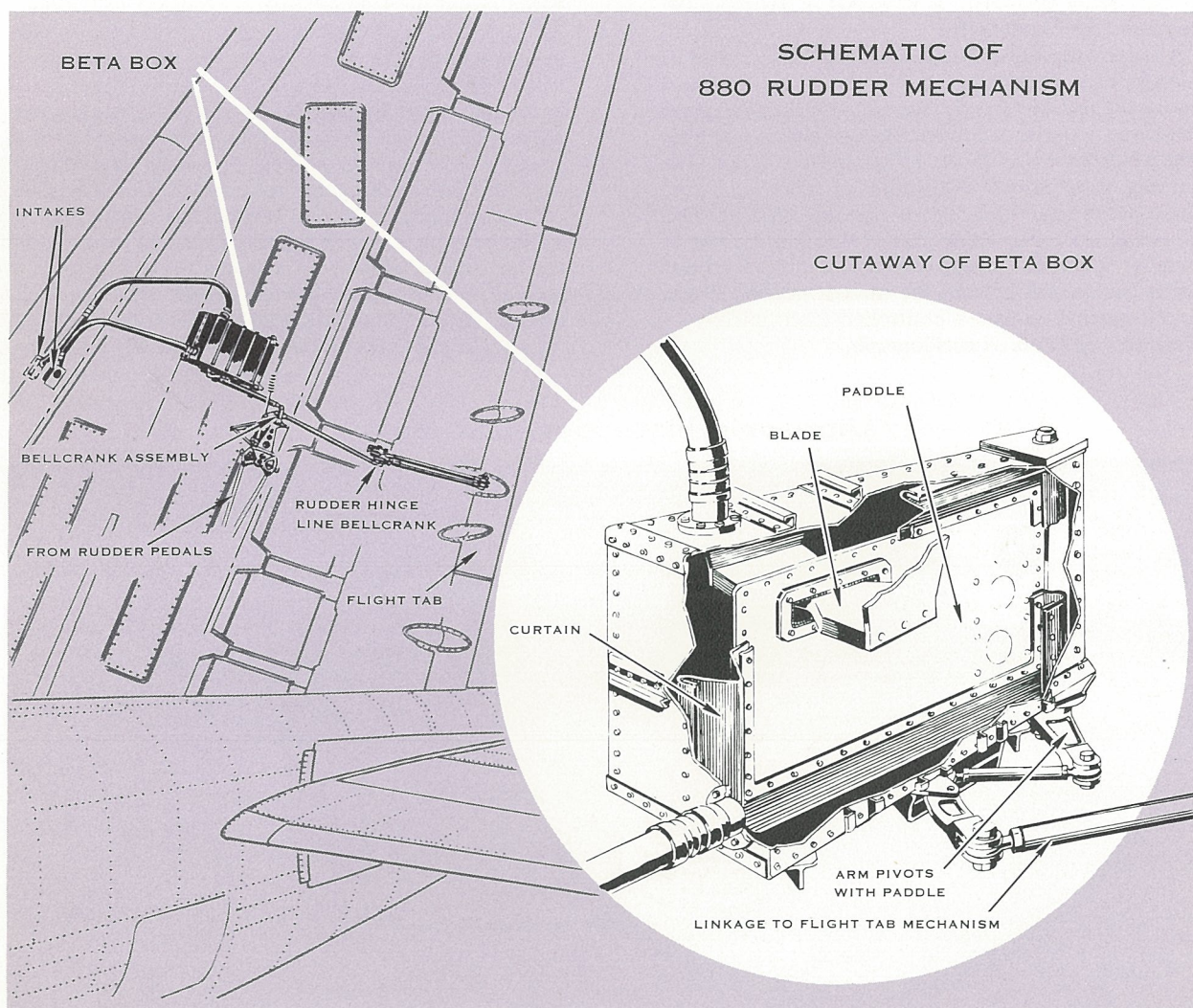
The way the beta box operates under these conditions is as follows: Flying with an outboard engine out, or with two engines out on the same side, requires lifting the wing on the side of the power loss and holding rudder against the asymmetric thrust. If the right-hand outboard engine is inoperative, for example, left rudder will be applied, and there will be a constant slip to the left. The left-hand side of the beta box will be pressurized, adding to, rather than opposing, the pilot's rudder pressure. With one engine out, the beta box would supply approximately 20 pounds — about a fifth — of the total force required at V_{MC} (minimum control speed). With two engines out on the same side, the added force would be even greater.

Simply summarized, the beta box tends to "weather-cock" the airplane; more formally phrased, it adds to pedal-free directional stability. In a slip to the left, as from a gust, the beta box exerts a pressure in the direction of left rudder to bring the airplane into line with

the airstream. In a slip to the left caused by a right-engine-out condition, the beta box exerts pressure in the direction of the left rudder held by the pilot.

For ground preflight check, the flight engineer actuates a test switch on the auxiliary panel above his main panels, and the pilot kicks hard rudder. A 180-pound force on the pedal closes a pressure switch in the beta box and a green light illuminates beside the test switch.

All Convair test aircraft were fitted with the side-slip-sensing feel system soon after the test program began. Test results exceeded anticipations; the system works, better than any that could be devised from "Q"-pressure loading. The installation is standard on all "880" aircraft, except for the heavier long-range version ("880" Model 22-M). The long-range "880" and the Convair 600 will employ power-boost or completely-powered rudder control systems, with artificial feel systems adapted to their needs.



the "Ultrasonic Look"

Various methods are used for non-destructive testing of parts that go into construction of Convair 880 and 600 jet airliners. These test methods range from the standard surface tests to an "ultrasonic look" into the very heart of metals and other materials.

Both Magnaflux and dye penetrant testing are utilized for the detection of surface or semi-surface flaws. The familiar Magnaflux process can detect defects in cast and wrought ferro-magnetic materials; dye-penetrant is used to test parts in much the same manner as the Magnaflux, but is applicable also to non-ferro-magnetic materials. Without these aids, minute flaws and feather cracks could be completely undetected.

The x-ray is a practical method for internal inspection of castings. A casting usually has an over-design margin to provide a safety factor beyond that which would be required if the casting were expected to be 100% perfect. X-ray sensitivity is generally limited to defects that are greater than 2% of the thickness of the part being examined. A flaw that is less than 2% cannot be readily detected.

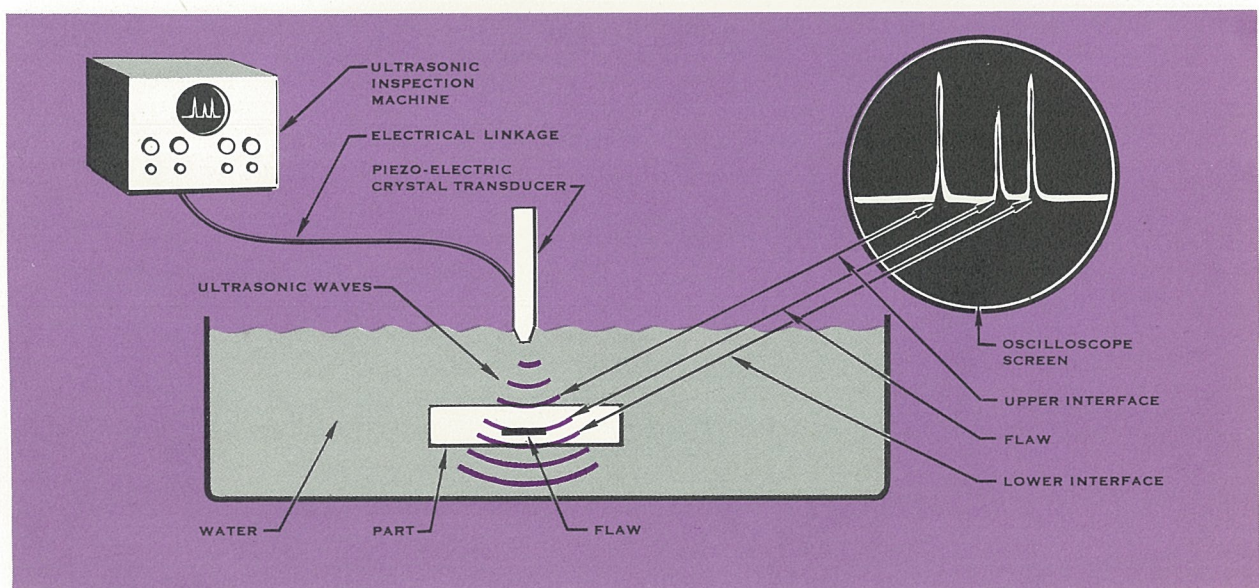
A large proportion of the structure of the aircraft is made from wrought metal and alloys. This includes the use of rolled, forged, and extruded high-strength alloys which derive a considerable proportion of their strength from being "worked" or cold formed. The working gives them uniformity of grain structure which permits non-destructive ultrasonic testing. This ultrasonic testing is accomplished through the use of sound frequencies ranging between 2 and 25 million cycles per second beyond the human hearing range. This frequency range — controlled electronically — becomes visible on an oscillograph.

Laboratory technicians, utilizing the "ultrasonic look" use a wide variety of techniques in accomplishing non-destructive testing with sonic waves . . . such variations as longitudinal, shear, and lamb wave modes, with focused and nonfocused transducers; the use of various kinds of crystals; and whether the contact or the immersion method is being employed.

It sounds quite complicated and, as a matter of fact, some of it is; however, the basic principle of the ultrasonic testing method is quite simple. The heart of the device is a transducer which is a wafer-thin crystal with piezo-electric qualities. "Piezo-electric" describes a trait of these crystal transducers. When subjected to an alternating electrical current, they change the electrical energy into mechanical energy (the ultrasonic sound waves of 2 to 25 million cycles per second). Also, when the mechanical energy of the sound wave strikes the crystal, the energy is converted back into an electrical impulse.

Coupled with the piezo-electric quality is a characteristic of the ultrasonic sound produced by the crystals; the sound will not travel through air. The transducer crystal, then, must be coupled to the piece being tested by a liquid such as water or oil. When properly arranged with respect to the test item, the ultrasonic test equipment applies electrical pulses at a rate of 60 per second. Between these pulses, the crystal is "silent" and "listens." When the sound strikes the nearest surface of the part being tested, some of the sound is reflected back and the "listening" crystal converts this into an electrical pulse which is made visible on an oscillograph as a pip. More of the same outgoing sound proceeds through the test piece and, on striking the far surface, is likewise reflected back to become a second pip on the oscillograph screen. One excellent quality of this sound test equipment is that the thickness of the part being tested makes virtually no differ-

Ultrasonic Inspection Schematic



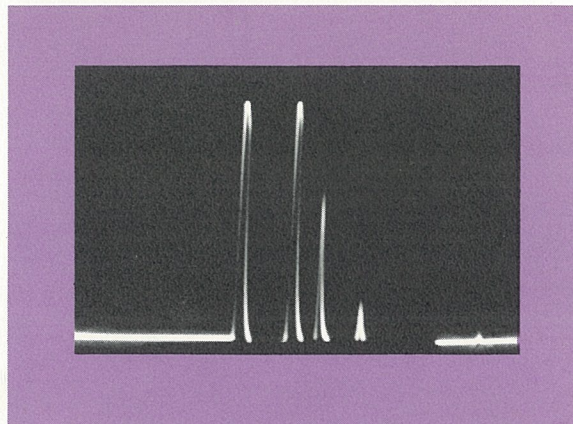
ence. The sound will react as described if the part is one tenth inch thick, or as thick as 35 feet.

Just as long as the entire thickness is uniform in structure (and consequently uniform in strength), only the outer face pips will appear. If there is a flaw inside, such as a minute wafer of gas which hasn't "healed" or fused together in the making of the part, or if there is a bit of foreign material, then it will be reflected back to form a third pip between the two outside pips. This spots the flaw immediately.

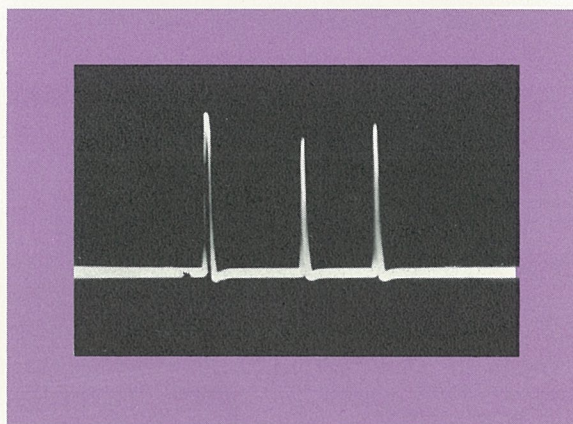
Not only does the "ultrasonic look" disclose that a flaw is in existence, but the appearance of the pip (or pips) can reveal just how deep in the part the flaw is, its size, and (to the experienced operator) what kind of flaw has been spotted.

Mill operators, supplying the billets, forgings, rolled, extruded, and welded rough stock for subsequent manufacturing operations, now utilize ultrasonic test equipment for establishing the integrity of the raw stock they supply. This precludes the costly procedure of returning defective material. Convair utilizes the "ultrasonic look" to check for desired quality before expensive machining and handling processes are started.

The "ultrasonic look" insures a quality product and gives promise of a means for determining how long a part can be used. It is believed that ultrasonic inspection may provide a means of determining the degree of fatigue that has developed before cracks actually start. It is known that fatigue failure begins to make itself evident by a sort of "molecular clutter" which can be detected with ultrasonic testing equipment. Knowing the response to ultrasonic probing, it may be possible to determine when a "retirement" age has been reached for structural parts which have contributed to a long and useful working life in service. Considerable research is being conducted along this line.

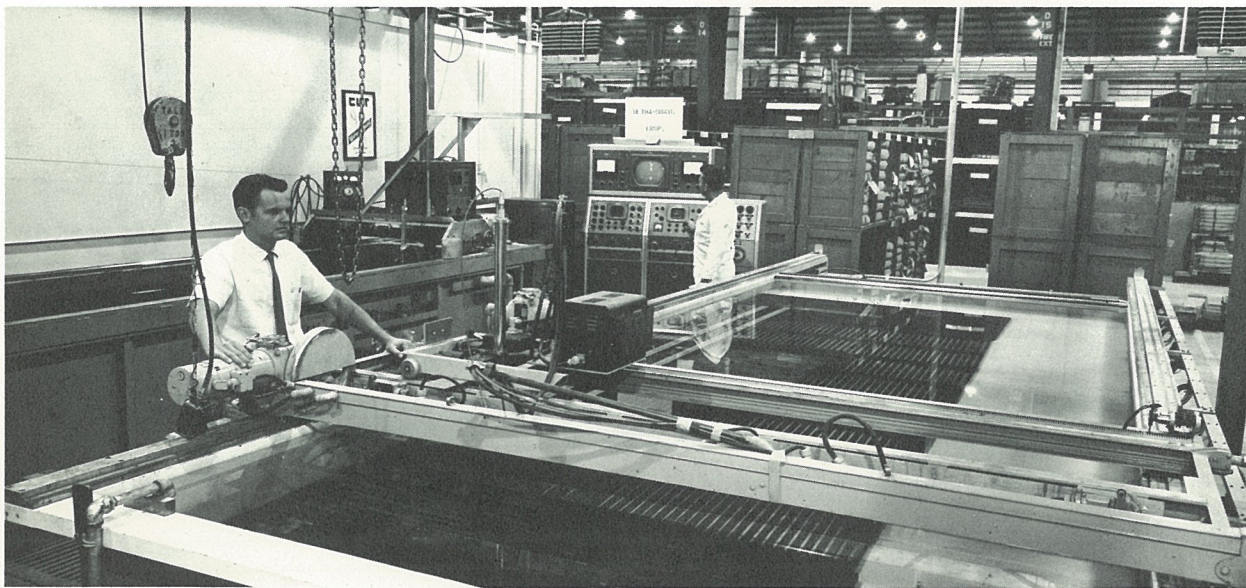


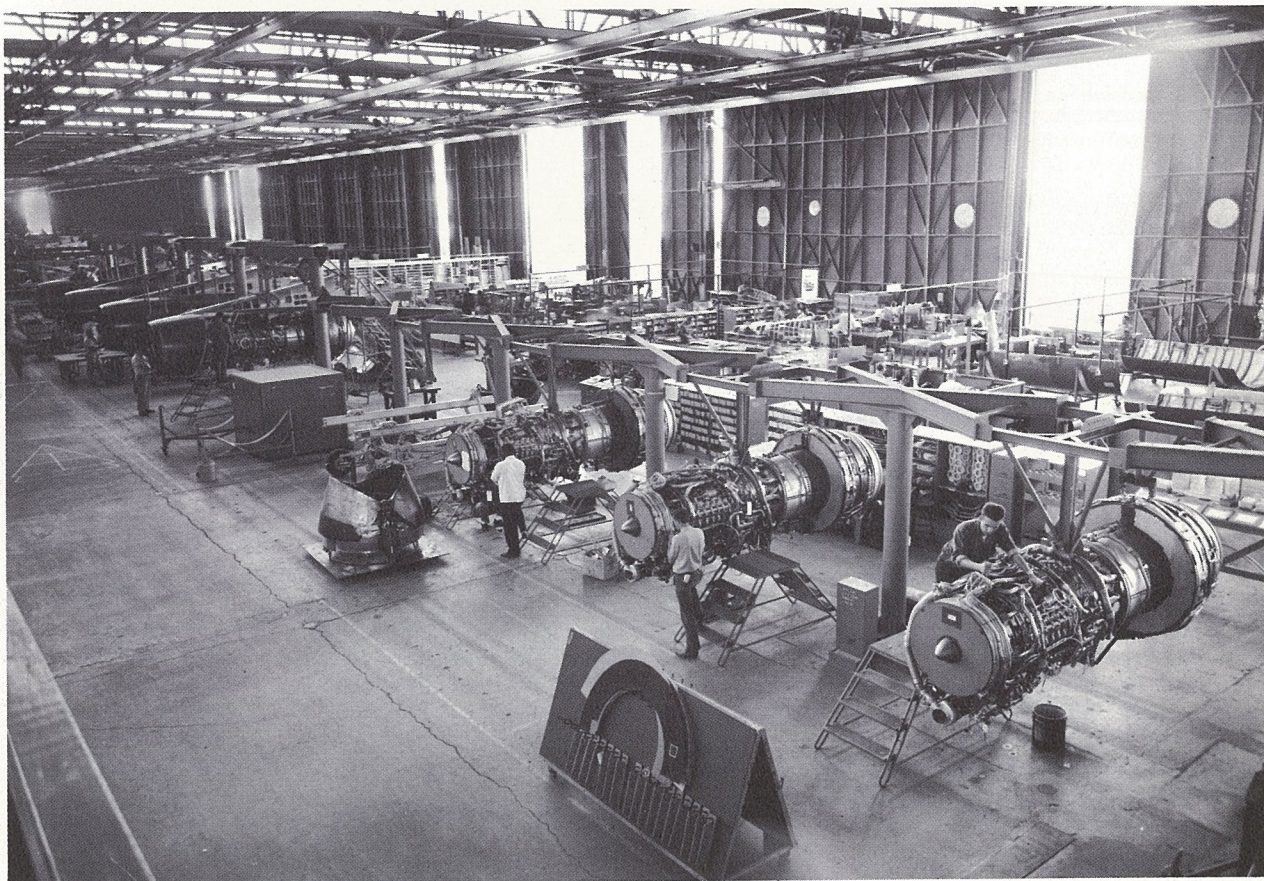
Oscillogram of discontinuities



Oscillograph presentation of an internal flaw, approximately 3/5 the way through the part, as depicted in the schematic on the opposite page.

Ultrasonic Inspection Equipment in Use





24 10

The date of the first flight of the Convair 600 draws near as the sleek, swept-wing, 635 mile-an-hour jet airliner nears completion.

The photograph above shows the Convair 600 engine buildup line where engines, pods, and pylons are assembled into power packages. In the foreground, being readied for mounting on pylons, are the powerful General Electric CJ805-23 aft fan jet engines. The smooth aerodynamically-shaped pods in the background enclose the engines and accessories, and turn

the power packages into highly efficient sources of propulsive power. In addition to contributing to greater speed, the aft fan application results in utmost fuel economy which extends the aircraft's range.

A clamshell thrust reverser, which attaches to the engine and forms the aft section of the power package, is shown to the left of the engine line. The "600" engine does not require sound suppressors because air-flow through the aft fan suppresses jet noise by mixing with the engine exhaust.

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Convair *Traveler*

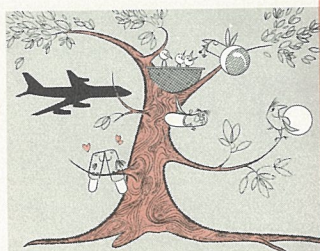
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In this Issue: Lamp Bulb Requirements - 880/600

VOLUME XII NUMBER 8 DECEMBER 1960

Convair Traveler



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OUR COVER

Artist Willis Goldsmith depicts airborne lamps as busy fireflies of various shapes, and "glowpower" to represent the 30 lamp varieties in nearly 100 lighting applications on the Convair 880/600 jet airliners.

Convair Traveler

VOLUME XII NUMBER 8 DECEMBER 1960

MANAGER, CUSTOMER SERVICE — J. J. ALKAZIN
CHIEF, TRANSPORT SERVICE — L. J. BORDELON
CHIEF, SERVICE PARTS — J. DOIG
CHIEF, SERVICE PUBLICATIONS — H. R. KENNEDY
EDITOR — GERTRUDE S. HUNTER
ART EDITOR — N. J. RUTHERFORD

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Sam Urshan

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Sam Urshan

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880/600

Sam Urshan

BACK COVER

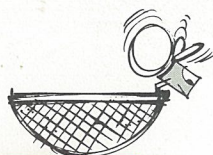
STRUCTURAL REPAIR MANUAL

Sam Urshan

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Lamp Bulb Requirements

880/600

There are 30 different kinds of light bulbs in use in Convair 880/600 jet airliners. They range from minute "wheat-sized" lamps that softly illuminate edge-lighted panels, to the sealed-beam flood lamps that furnish 800,000 candle power for night landings.

Incandescent lamps, used in the majority of lighting applications, are powered by the aircraft 115/200-volt electrical system, stepped down to 28 volts ac and dc. Fluorescent tubes that illuminate the passenger cabin, lounge, coat compartments, and lavatories operate on the 115-volt ac system. Also using 115-volt ac are the lamps containing neon gas. Six-volt current is supplied to the smaller lamps that illuminate the instruments and controls; 28-volt lamps are used for emergency lighting.

Table of Requirements

CABIN - GENERAL

FUNCTION	DESCRIPTION	NUMBER
Cove Lighting	Fluorescent	95-46400-002
Cove Lighting	Fluorescent	95-46400-003
Call Lights	Clear	MS-25231-313
Ordinance Signs	Clear	MS-25231-313
Overhead Aisle Lts	Clear	MS-25233-303
Overhead Aisle Lts	Clear	MS-15570-6
Pass. Reading Lts	Clear	95-47103-005

AFT LAVATORIES

Outbd Mirror Lt	Fluorescent	95-46400-002
Inbd Mirror Lt	Fluorescent	95-46400-003
Commode Lt	Fluorescent	95-46400-003
Door - "Occupied - Vacant" Sign	Clear	MS-25231-313
Call Lts	Clear	MS-25237-327
"Occupied - Vacant" Sign	Clear	95-47001-007

FWD LAVATORY

Outbd Mirror Lt	Fluorescent	95-46400-002
Inbd Mirror Lt	Fluorescent	95-46400-003
Commode Lts	Fluorescent	95-46400-003
"Return to Cabin" Sign	Clear	95-47001-007
Door "Occupied - Vacant" Sign	Clear	MS-25231-313

BUFFET AREAS

FUNCTION	DESCRIPTION	NUMBER
Illumination Lts	Clear	MS-25232-307
Call Lts	Clear	MS-25231-313

LOUNGE - GENERAL

Valance Lts	Fluorescent	95-46400-003
Ceiling Lts	Clear	MS-25233-303
Pass. Reading Lts	Clear	95-47013-005
Table Lamp	Inside Fr	95-47013-002
Fwd Partition	Clear	MS-25231-313
Ordinance Signs		

COAT COMPTS

LH Fwd Illumination	Fluorescent	95-46400-002
RH Fwd Illumination	Fluorescent	95-46400-002
Aft Illumination	Fluorescent	95-46400-002

PORTABLE COAT COMPT

"No Smoking - Fasten Seat Belt" Sign	Clear	MS-25231-313
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FWD & AFT PASSENGER ENTRANCES

Overhead Illum	Silver Bowl	MS-35480-2
Threshold Illum	Clear	MS-25069-1495
Panel Edge Lights	Clear	MS-25237-327
Entryway - Exit Sign	Clear	95-47001-007
Exit Signs	Clear	95-47001-007

FWD & AFT SERVICE ENTRANCES

Emergency Exit Sign	Clear	95-47001-007
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FLIGHT COMPARTMENT - GENERAL

Fwd Dome Lt	Clear	MS-25232-307
Fwd Dome Lt	Clear	95-47013-001
Aft Dome Lt	Clear	MS-25232-307
Aft Dome Lt	Clear	95-47013-001
2nd Ofcr's Table Flood (600)	Clear	MS-25069-1495

INSTRUMENT PANEL

Control Lts	Clear	MS-25231-313
		95-47001-002
Instrument Lts	Clear	MS-25237-328
Contr Panel Edge Lts	Clear	MS-25237-327
Magnetic Compass	Clear	MS-25237-328
		MS-25237-327

PILOTS' CONSOLES

Console Lts	Clear	MS-25069-1495
Panel Edge Lts	Clear	MS-25237-327

PILOTS' AUXILIARY PANEL		
FUNCTION	DESCRIPTION	NUMBER
Panel Edge Lts	Clear	MS-25237-327
Emergency Air Brake Lt	Clear	MS-25237-328
"Parking Brake ON" Lt	Clear	MS-25231-313

PARKING BRAKE HANDLE		
"Parking Brake ON" Lt	Clear	MS-25237-327

PILOTS' GLARE SHIELD		
Instr Panel Flood Lt	Fluorescent	95-46400-002
"Agent Out"	Clear	MS-25231-313
Instr Panel Illumination	Clear	MS-25069-1495
Fire Control Sw Warn.	Clear	MS-25237-327

PILOTS' OVERHEAD CONTROL PANEL		
Panel Control Lts	Clear	MS-25231-313
Panel Control Lts (600)	Clear	95-46501-003
Panel Edge Lts	Clear	MS-25237-327
Flood Lt	Silver Bowl	95-47011-001

PEDESTAL		
Fwd Control Lts	Clear	MS-25231-313
Aft Radio Control Edge Lts	Clear	MS-25237-327
Panel Edge Lts	Clear	MS-25237-327
Tune Lt	Clear	MS-25237-327
Flood Lt	Silver Bowl	95-47011-001

MAP READING		
Pilot's Lts	Silver Bowl	95-47014-001
		95-47011-001
Copilot's Lts	Silver Bowl	95-47014-001
		95-47011-001
Observer's Lts (600)	Silver Bowl	95-47014-001

FLIGHT ENGINEER'S STATION		
Table Flood Lt (600)	Clear	MS-25069-1495
Panel Flood Lt	Clear	95-47013-004
Panel Flood Lt (600)	Fluorescent	95-46400-003
Panel Control Lts	Clear	MS-25231-313
Panel Edge Lts	Clear	MS-25237-327
Emer - Ign Power ON	Clear	95-46501-003

CIRCUIT BREAKER PANEL		
Lower Panel Flood Lt (600)	Clear	MS-25231-313
Radio Panel Flood Lt (600)	Clear	MS-25069-1495

ELECTRONICS COMPARTMENT		
FUNCTION	DESCRIPTION	NUMBER
Compt Illumination	Silver Bowl	95-47013-003
Sta 321 Illumination	Silver Bowl	95-47013-003
Sta 359 Illumination	Silver Bowl	MS-25235-311
Radio Rack Edge Lt	Clear	MS-25237-327

HYDRAULIC COMPARTMENT		
Compt Illumination	Silver Bowl	MS-25235-311

FWD & AFT CARGO COMPARTMENTS		
Door Spot Lts	Silver Bowl	95-47011-001
Overhead Illu	Silver Bowl	MS-25235-311

AIR CONDITIONING COMPARTMENT		
Compt Illumination	Clear	MS-25234-308

TAIL CONE COMPARTMENT		
Compt Illumination	Silver Bowl	95-47013-003

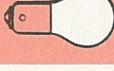
LANDING GEAR WHEEL WELLS		
NLG Illumination	Silver Bowl	MS-25235-311
MGL Illumination	Silver Bowl	MS-25235-311

EXTERNAL LIGHTS		
Wing Leading Edge Taxi & Turn-off Lts	Clear	4551
Wing Leading Edge Signal & Aux Ldg Lts	Clear	MS-25242-4559
Retractable Ldg Lts	Clear	4616
		4615
Wing Tip Position	Silver Bowl	4174
Ice Illumination	Clear	4594
Anti-Collision Lts	Silver Bowl	95-47011-002
Tail Position Lt	Clear	95-47014-002

PYLON		
Refuel Panels	Clear	MS-25237-327
SPARE LAMP	Clear	MS-25232-307
STOWAGE BOX	Clear	MS-25231-313
	Clear	MS-25069-1495
	Clear	MS-25237-327
	Clear	MS-25237-328
	Clear	95-47013-001
	Clear	95-47013-004
	Clear	95-47001-002
	Silver Bowl	95-47014-001
	Silver Bowl	95-47011-001

SPARE LAMP	Silver Bowl	MS-35480-2
STOWAGE BOX (600)	Clear	MS-25237-327
	Clear	95-47001-007
	Clear	MS-25233-303
	Clear	95-47013-005

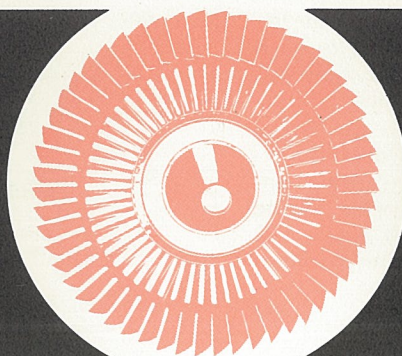
Lamp Bulb Description

BULB	NUMBER	TYPE	AMPS	VOLTS	WATTS	C.P.
	95-46400-002 (GE 5108WW) (SYLVANIA-F8T5/RS/WW)	FLUOR	.170	47	8	
	95-46400-003 (GE 5113WW) (SYLVANIA-F13T5/RS/WW)	FLUOR	.180	85	13	
	95-46501-003 (GE NE51H)	CLEAR	2 MA	115	.04	
	95-47001-002 MS 15582 (GE 47)	CLEAR	.15	6.3	.945	
	95-47001-007 (GE 1820)	CLEAR	.10	28	2.8	
	95-47011-001 (GRIMES-A8115-24)	SILVER BOWL		28	20	
	95-47011-002 (GRIMES-A-7079A24)	SILVER BOWL		28	40	
	95-47013-001 (GE 309)	CLEAR	.90	28	25.2	32
	95-47013-002 (GE 309IF)	INSIDE FROSTED	.90	28	25.2	32
	95-47013-003 (GE 309SB)	SILVER BOWL	.90	28	25.2	32
	95-47013-004 (GE 1309)	CLEAR	.52	28	14.6	15
	95-47013-005 MS35478-5 (GE 305)	CLEAR	.51	28	14.3	15
	95-47014-001 (GE 836) TWO FILAMENTS	SILVER BOWL	.68/.68	28/28	19.0/19.0	
	95-47014-002 AN3139-312 (GE 312)	CLEAR	1.29	28	36.1	50
	MS25235-311 (GE 311)	CLEAR	1.29	28	36.1	50

LAMP BULB DESCRIPTION CONTINUED

BULB	NUMBER	TYPE	AMPS	VOLTS	WATTS	C.P.
	95-47001-005 MS25069-1495 (GE 1495)	CLEAR	.3	28	8.4	6
	95-47000-001 AN3121-313 MS25231-313 (GE 313)	CLEAR	.17	28	4.76	
	MS25232-307 (GE 307)	CLEAR	.67	28	18.8	21
	MS25233-303 (GE 303)	CLEAR	.3	28	8.4	6
	MS25234-308 (GE 308)	CLEAR	.67	28	18.8	21
	95-47000-201 MS25235-SB311 (GE 311SB)	SILVER BOWL	1.29	28	36.1	50
	MS25237-327 (GE 327)	CLEAR	.04	28	1.12	.34
	95-47000-400 MS25237-328 (GE 328)	CLEAR	.2	6	1.2	.34 AT 5 VOLTS
	95-47800-004 MS25242-4559 (GE 4559)	CLEAR	21.4	28	600	600,000 BEAM C.P.
 SILVER BOWL OUTSIDE FROSTED	95-47012-002 MS35480-2 (GE 1385)	SILVER BOWL	.714	28	20	
	95-47016-001 (GRIMES-A-4174-24)	SILVER BOWL	1.44	28	40	50
	95-47800-009 (GE 4551)	CLEAR	8.93	28	250	
	95-47800-005 (GE 4594)	CLEAR	3.57	28	100	
	95-47800-007 (GE 4615)	CLEAR	35.7	28	1000	800,000 BEAM C.P.
	95-47800-008 (GE 4616)	CLEAR	21.4	28	600	570,000 BEAM C.P.

Turbofan Engines



... advantages of turbofan engines are many ...

The variation in air transportation speeds is so great that it takes more than one type of power plant to efficiently serve the entire speed range. For a generation, the reciprocating engine bore the whole load of powered aircraft, but today the task is divided among different types of power plants according to the speeds to be encountered on a mission.

The straight turbojet engine is in its element at speeds approaching Mach 1.5. The state of the art of current commercial jet airliners does not extend into this supersonic range, yet it has reached far beyond the propeller efficiency limit of Mach .5.

By merging the low-speed advantages of the propeller with the high-speed features of the pure jet there evolved the shrouded propeller (fan) and turbojet engine combination which resulted in the turbofan. Its best operating range—Mach .8 to Mach .9. Often thought of during the various stages of jet engine development, the turbofan concept was reluctantly cast aside for many years to await the outcome and perfection of the straight turbojet engine. Now that the turbojet has attained a high degree of efficiency and reliability, the turbofan engine is rapidly taking its rightful place as the successor to the basic gas turbine engine for subsonic use.

The turbofan engine has a fan at either the forward or aft portion of the engine. The fan assembly, which is driven by energy derived from the jet engine, acts as a propeller that increases mass airflow and consequently increases engine thrust. The fan compresses inlet air by virtue of its shroud and, in some designs, discharges it at the rear of the engine where it is mixed with engine gases and is exhausted out the tailpipe.

The advantages of the turbofan engine are manifold. With very little increase in weight and complexity, the incorporation of the fan to the basic gas generator results in an impressive reduction in specific fuel consumption (SFC). This is especially attractive to commercial operators who have long been aware of the inefficient relationship between the takeoff thrust and the cruise thrust of existing straight turbojet engines. In order to have economical cruise thrust in the desired range of Mach .8 to Mach .9, compromises had to be made in the takeoff thrust regions of conventional turbojet engines.

Improvements of the turbofan over the straight turbojet engine include the following: 1) no increase in fuel flow for a given power setting; 2) an increase

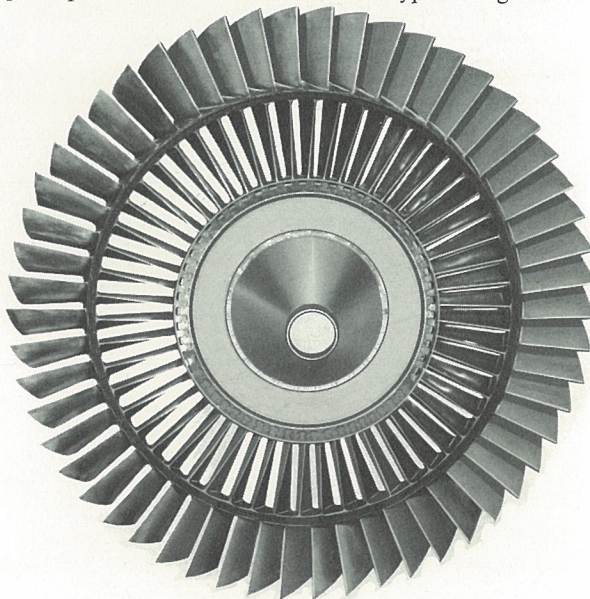
of over one-third in takeoff thrust; 3) approximately one-third increase in climb thrust; and 4) as high as 18 percent increase in cruise thrust.

There are several configurations of turbofan or turbofan-type engines that are currently powering commercial transports, or are in various stages of development. These include the turboprop, the bypass, the forward-fan, and the aft-fan engines.

The turboprop, a turbine engine driving a propeller, operates best in a true airspeed range between 300 and 400 knots. Approximately 90 percent of the thrust of a turboprop engine is derived from its propeller, which does not operate in a duct, but is geared down for best efficiency. At higher speeds, the turboprop begins to lose some of its effective thrust, resulting from a decrease in the differential velocity of the air passing through the propeller.

One type of bypass engine has a shrouded fan forward of the basic turbojet that is driven directly by a turbine at the rear of the engine. Part of the inlet air is bypassed around the turbojet engine where it adds thrust by becoming compressed and is exhausted out the tailpipe with the engine gases.

The forward-fan turbofan engine operates on a principle similar to that of the bypass engine. A



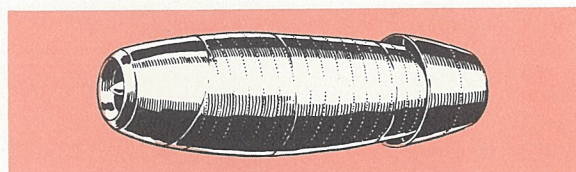
INTEGRAL TURBINE-COMPRESSOR AFT FAN

ducted fan assembly, installed at the front of a turbo-jet engine, compresses air for the jet engine through its inner portion, while its outer periphery compresses air for added thrust. The air from the outer portion of the fan (for existing installations) is discharged well forward on the engine nacelle and does not exhaust with the engine gases. Some designs, being considered, bypass the air back to the rear of the engine where it is discharged with the exhaust gases. The forward fan is mechanically integrated with the compressor and is driven directly by the turbine.

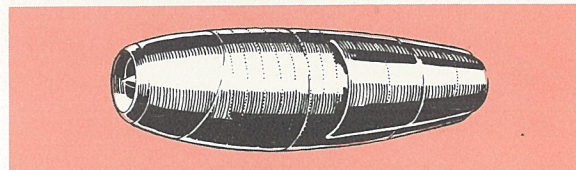
The aft-fan engine is similar in principle to the forward-fan design, but has a free-wheeling turbine-compressor stage aft of the basic jet engine. The single aft fan is driven by engine exhaust gases that pass through its inner turbine portion. Compressor blades on the outer periphery generate additional thrust by increasing the mass air flow. The aft-fan is probably the most simple of the current turbofan designs.

There are three nacelle configurations applicable to aft-fan engines. These are the short-cowl annular inlet that takes fan air well aft of the primary air inlet, the cheek inlets with fan air entering through ducts on both sides of the nacelle, and the common inlet which takes in both fan air and gas generator air from a single inlet.

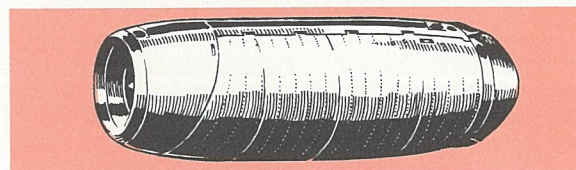
Convair chose the common inlet design for its "600" aft-fan engine nacelles because of the minimum drag characteristics of the single duct. These engines, designated the CJ805-23, are built by General Electric and consist of the well-proved basic CJ805 turbojet to which the aft-fan assembly has been added.



SHORT-COWL ANNULAR INLET

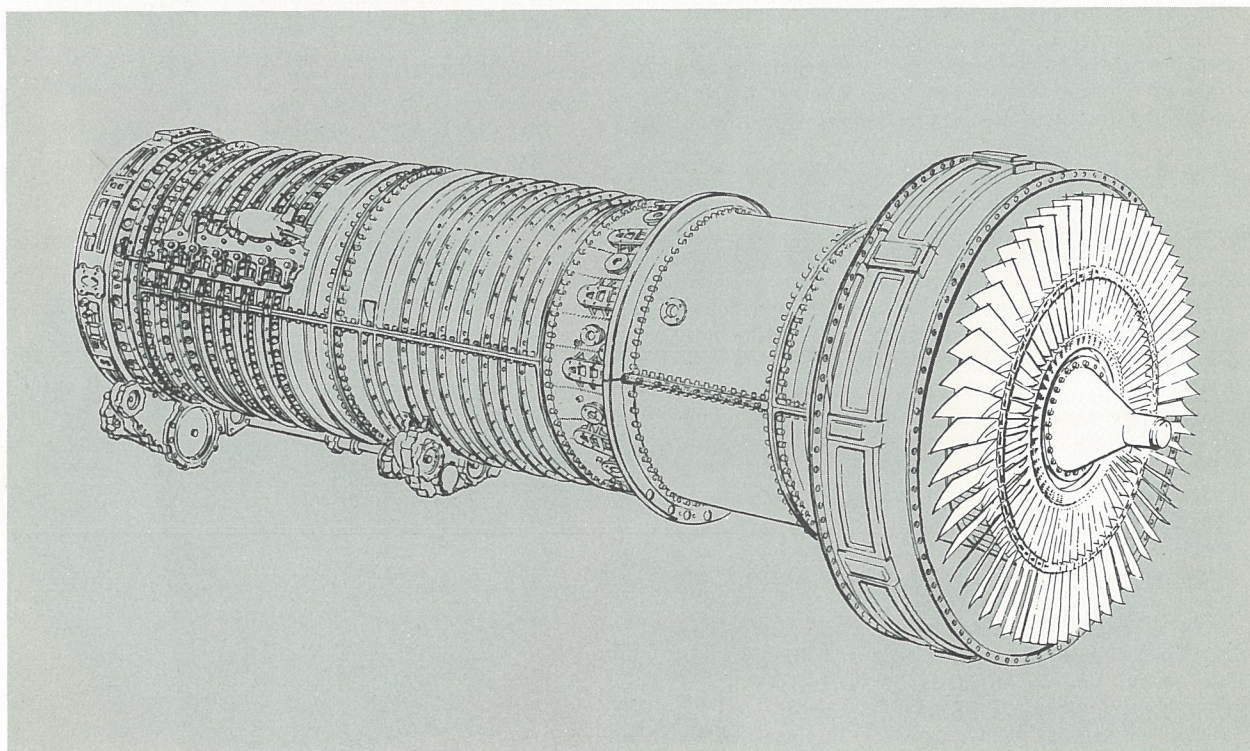


CHEEK INLETS



COMMON INLET

Two CJ805-23 aft-fan engines, complete with common inlet nacelles and supporting pylons, have been installed on an RB-66 bomber, leased by General Electric for engine flight testing. The engines and pods are the same as those that will power the Convair 600. On the initial test flight, the aft-fan powered bomber climbed to an altitude of 35,000 feet and flew at speeds up to Mach .85—perfect for present-day commercial jet airliners.



Convair 600 aft fan engine — G.E. CJ805-23 — is basic jet engine with free-wheeling fan assembly on aft end.

Antennas and Their Function

880/600

A reel antenna, extending far below an airliner, might have certain advantages over a smaller unit encased in a streamlined cover, but the changeover to modern jet speeds has ruled out the bare wires of a decade ago. Consider the possible consequences of a whipping, uncontrolled weighted wire trailing from a jet airliner traveling at nearly the speed of sound! Even a thin wire stretched from a wing tip to the rudder would present enormous drag at subsonic speeds.

Antenna design has kept pace with the rapid advancement of aircraft design. Despite the increase in communications and navigation equipment installed in modern jet airliners, such as the Convair 880 and 600, and the resultant increase in associated antennas, meticulous design and advantageous placement of the units have kept antenna drag to the barest minimum.

The Convair 880/600 jet airliners are equipped with 14 to 18 radio communication and navigation system antennas, the number of antenna installations varying with customer requirements. All 880/600 aircraft have structural provisions for 18 units.

The function of each antenna determines its size, location, and the method of installation. All antennas are on, or near, the exterior skin of the aircraft (flush type), or extend into the air stream (blade type).

The flush type antenna is mounted in a recessed cavity covered by a special type of laminated fiberglass surface that is flush with and follows the contour of the exterior skin of the aircraft. Some of the flush type antennas have their elements imbedded in the fiberglass cover. The blade, or minimum drag, type antenna, protrudes from the aircraft exterior and is aerodynamically shaped to offer the least amount of air resistance when the aircraft is in flight. The elements of the blade type antenna are shaped to an aerodynamic contour or may be encased in a laminated fiberglass streamlined shape.

On page 11 is a list of the antennas, their function, and location on Convair 880/600 jet airliners.

The No. 1 VHF (Very High Frequency) Communications antenna is a vertically-polarized ground-plane blade type antenna used in voice communication with towers, ground stations, and other aircraft. It is located on the lower fuselage centerline of the airplane at station 458.12 on both the "880" and "600."

The No. 2 VHF Communications antenna is a vertically-polarized top-loaded ground plane antenna for the aircraft No. 2 transmitter-receiver. It is flush-mounted on the upper side of the airplane fuselage dorsal fairing between stations 784.45 and 841.90 on

the "880," and between stations 841.89 and 899.34 on the "600."

Provisions are included for a third VHF Communications antenna similar to the No. 1 unit. These provisions are located on the top center line of the airplane at station 384.5, just aft of the cockpit area.

The Weather Radar antenna is a parabolic (dish-shaped) revolving antenna that radiates and receives radar signals for weather surveillance and terrain mapping. The antenna is mounted within the plastic radome on the station 152 bulkhead for both the Convair 880 and 600.

The Glide Slope antenna is a horizontally-polarized semi-loop antenna that receives glide slope signals for instrument approaches. It is mounted on the station 152 bulkhead within the radome, above the radar antenna at waterline 79.0 on both the Convair 880 and 600.

The VHF Navigation antenna is horizontally-polarized and is used for receiving VOR (VHF Omnidirectional Radio) and ILS (Instrument Landing System) localizer signals, and tower and voice communications. On the Convair 600, the VHF Navigation antenna is an external type consisting of a loop antenna, mounted horizontally in the vertical stabilizer and contained within aerodynamic fairings that extend slightly on both sides of the stabilizer at waterline 311. On the Convair 880, the VHF Navigation antenna radiating elements are embedded in two flush-mounted doors that are located on each side of the vertical stabilizer at waterline 311.

The Marker Beacon antenna is horizontally-polarized and receives marker beacon signals that provide the pilots with audible and light indications of the exact position of the airplane along glide slope paths and along range station legs. The antenna is a low-silhouette blade, or stub, type installed on the lower fuselage centerline of the aircraft, slightly forward of the wing leading edge, at station 533.25 on the Convair 880, and at station 381.85 on the Convair 600.

The ADF (Automatic Direction Finding) Sense antennas, Numbers 1 and 2, are non-directional signal sensing devices used in conjunction with the ADF Loop antennas in receiving vertically-polarized signals to provide automatic direction finding. The ADF Sense antennas comprise aluminum alloy antenna plates bonded to fiberglass fairings. They are flush-mounted in the dorsal fairing atop the airplane fuselage and are positioned between stations 841.90 and 1068.05 on the Convair 880, and between stations 889.34 and 1125.46 on the Convair 600.

Two ADF Antenna Couplers match the low capacitance of the ADF Sense antennas to the high input capacitance of the ADF receivers. Both antenna couplers are located under a small section of the antenna fairing between the two ADF Sense antennas.

The two ADF Loop antennas are flush-mounted on the Convair 880, and are located on the bottom centerline of the airplane fuselage forward of the wing leading edge. No. 1 ADF Loop antenna is located between stations 508 and 527; No. 2 is between stations 546 and 565. On the Convair 600, both ADF Loop antennas are flush-mounted on the centerline of the airplane

upper surface between stations 565 and 584, and between stations 603 and 622, aft of the cockpit.

No. 1 and No. 2 ATC (Air Traffic Control) Beacon antennas are vertically polarized and are used to receive and radiate radar beacon transponder signals that enable the airplane to be tracked through heavy ground clutter and precipitation. Both antennas are small blade types that are located on the bottom centerline of the airplane, as close as practicable to the receiver and transmitter, so as to eliminate high cable losses at the frequencies involved. On the Convair 880 and 600, No. 1 is located at station 422.5; No. 2 antenna is located at station 498.5 on the 880, and at station 517.0 on the 600.

The two DMET (Distance Measuring Equipment — TACAN) antennas radiate and receive vertically-polarized omnidirectional signals which are timed to determine distance of the airplane from interrogated ground beacons. The DMET antennas are small external blades which are characteristic of the UHF (Ultra High Frequency) on which the system operates. Such high operating frequencies make it necessary to position the antennas as close as possible to the electronic equipment racks to minimize cable losses. Both No. 1 and No. 2 DMET antennas are located on the airplane centerline. On both the 880 and 600, the No. 1 antenna is located on the underside of the fuselage at station 315.90; the No. 2 antenna is located on top of the fuselage at station 310.25.

The Terrain Warning Radar antenna, installed on some Convair 880's, is horizontally polarized in the fore-and-aft direction of the aircraft, and is used to warn of the proximity of terrain obstructions, and to supplement the aircraft altimeter. The antenna is the flush type, mounted in a cavity on the bottom centerline of the airplane forward of the wing leading edge at station 384.5.

The entire 880/600 airframe constitutes the HF Communications (High Frequency Liaison) antenna. It is excited by an isolated flush type antenna that forms the tip of the vertical stabilizer between waterlines 389 and 359. The tip antenna feeds across a 10-inch isolating gap of laminated fiberglass panels and spars that take the place of the metal structure in the gap.

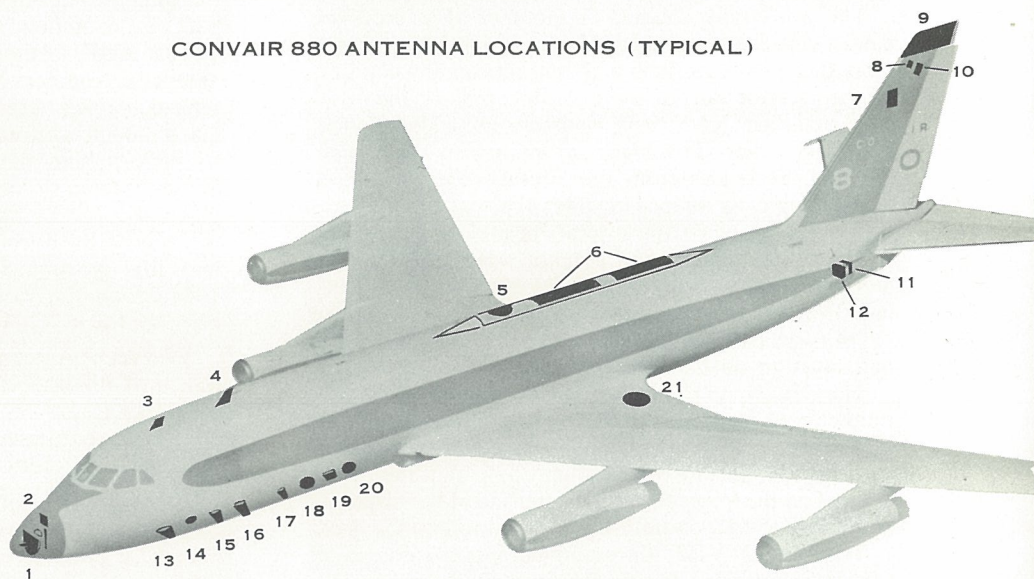
There are structural provisions for two Antenna Couplers on the 880/600 with one or two installed, depending on customer requirements. The HF Antenna Coupler matches the aircraft antenna to the transmitter at the frequency assigned in the operating band. A lightning arrestor and a transfer relay are attached to the single or double couplers. The units are located in the vertical fin, just under the fiberglass isolating gap of the HF Communications antenna.

Provisions for two Antenna Coupler Controls are also included in the airplane, with either one or two of the units installed. The function of the Antenna Coupler Control is to control the positioning of the components in the transmitting coupler. The coupler control unit contains the HF receiving coupler and also the LORAN (Long Range Navigation) coupler. Antenna Coupler Controls are located in the tail cone of the airplane, aft of the cabin pressure bulkhead.

On all models of the Convair 880/600, structural provisions are furnished for the installation of a Doppler Radar antenna. The Doppler Radar determines aircraft drift and ground speed by radiating pencil beams of high-intensity pulses, receiving the reflected return signals, and evaluating the information relative to motion over the earth's surface. The Doppler Radar antenna is flush type, recessed in a cavity in the bottom of the left wing near the fuselage.

- 1 WEATHER RADAR
- 2 GLIDE SLOPE
- 3 DMET NO. 2*
- 4 VHF COMM. NO. 3*
- 5 VHF COMM. NO. 2
- 6 ADF NO. 1 & 2 SENSE
- 7 VHF NAVIGATION
- 8 HF COUPLER NO. 1
- 9 HF COMM.
- 10 HF COUPLER NO. 2*
- 11 COUPLER CONT. NO. 2*
- 12 COUPLER CONT. NO. 1
- 13 DMET NO. 1
- 14 TERRAIN WARNING
- 15 ATC TRANSP. NO. 1
- 16 VHF COMM. NO. 1
- 17 ATC TRANSP. NO. 2*
- 18 ADF NO. 1 LOOP
- 19 MARKER BEACON
- 20 ADF NO. 2 LOOP
- 21 DOPPLER RADAR*
- * STRUCTURAL PROV.

CONVAIR 880 ANTENNA LOCATIONS (TYPICAL)



Antenna Chart

ANTENNA	AIRPLANE	LOCATION	TYPE
ADF NO. 1 LOOP	880 600	Lower Surface of Fuselage — Stas 508 - 527 Upper Surface of Fuselage — Stas 565 - 584	Flush
ADF NO. 2 LOOP	880 600	Lower Surface of Fuselage — Stas 546 - 565 Upper Surface of Fuselage — Stas 603 - 622	Flush
ADF NO. 1 & NO. 2 SENSE	880 600	Imbedded in Fiberglass Panel of Fuselage Dorsal Fin between Stas 841.90 and 1068.05 Imbedded in Fiberglass Panel of Fuselage Dorsal Fin between Stas 889.34 and 1125.46	Flush
HF COMMUNICATIONS	880/600	Top of Vertical Fin between WL's 389 and 359	Flush
HF COUPLER NO. 1	880/600	In LH Side of Vertical Fin	Inside
HF COUPLER NO. 2 (Structural Prov)	880/600	In LH Side of Vertical Fin	Inside
ANTENNA COUPLER CONTROL NO. 1	880/600	In Tail Cone, RH Side, Aft of Pressure Bulkhead — Unpressurized Area	Inside
ANTENNA COUPLER CONTROL NO. 2 (Structural Prov)	880/600	In Tail Cone, RH Side, Aft of Pressure Bulkhead — Unpressurized Area	Inside
VHF COMMUNICATIONS NO. 1	880/600	Lower Surface of Fuselage at Sta 458.12	Blade
VHF COMMUNICATIONS NO. 2	880 600	Imbedded in Dorsal Fin Cover between Stas 784.45 & 841.90 Imbedded in Dorsal Fin Cover between Stas 841.89 & 899.34	Flush
VHF COMMUNICATIONS NO. 3 (Struct Prov)	880	On Upper Surface of Fuselage at Sta 384.5	Blade
VHF NAVIGATION	880 880 M/600	Imbedded in RH and LH Fiberglass Doors on Vertical Fin at WL 311 Within Fiberglass Fairings, RH and LH Sides of Vertical Fin at WL 311	Flush Loop
MARKER BEACON	880 600	Lower Surface of Fuselage at Sta 533.25 Lower Surface of Fuselage at Sta 381.85	Blade
GLIDE SLOPE	880/600	In Radome, Sta 152 Bulkhead above Radar Antenna	Inside
WEATHER RADAR	880/600	In Radome, Sta 152 Bulkhead below Glide Slope Antenna	Inside
TERRAIN WARNING	TWA 880	Lower Surface of Fuselage, Sta 384.5	Flush
ATC TRANSPONDER BEACON NO. 1	880/600	Lower Surface of Fuselage, Sta 422.5	Blade
ATC TRANSPONDER BEACON NO. 2 (Structural Prov)	880 600	Lower Surface of Fuselage, Sta 498.5 Lower Surface of Fuselage, Sta 517.0	Blade
DMET NO. 1	880/600	Lower Surface of Fuselage, Sta 315.9	Blade
DMET NO. 2 (Structural Prov)	880/600	Upper Surface of Fuselage, Sta 310.25	Blade
DOPPLER RADAR (Structural Prov)	880/600	Under Left Wing near Fuselage	Flush

Structural Repair Manual

The Structural Repair Manual for the Convair 880 and 600 jet airliners contains information on the inspection, evaluation, and accomplishment of repairs for damage that may occur to the primary and secondary structures of the airplane. Repairs of extensive damage to primary structures are also included in the manual. The manual does not contain servicing, testing, trouble-shooting, or the replacement of system components, since these subjects are covered in the Maintenance Manual.

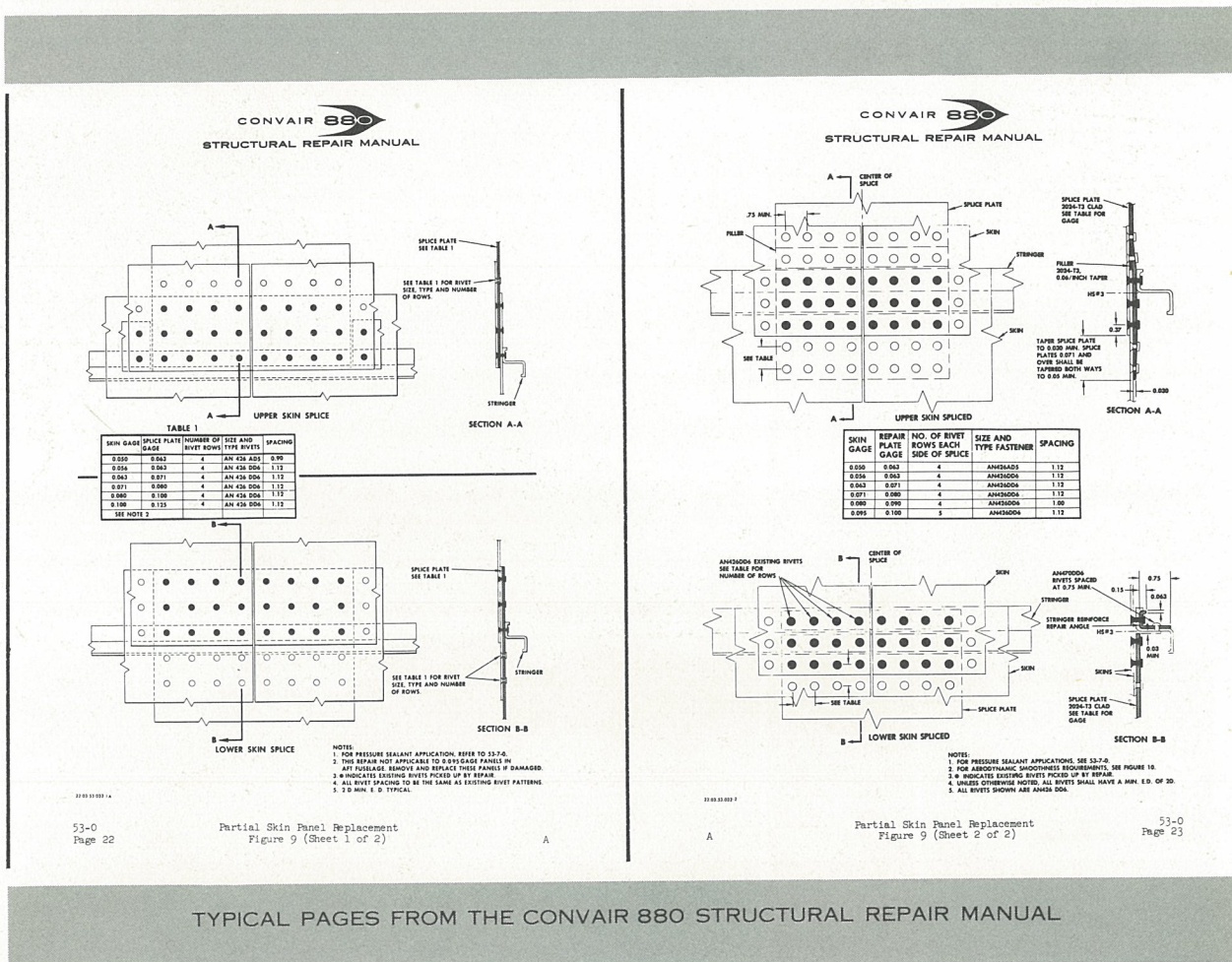
Different types of repairs, materials, and processes peculiar to Convair's manufacturing methods are thoroughly described and illustrated. Detailed instructions, data, and step-by-step illustrations on the repair of both typical and specific structural damage are clearly presented. Application of the recommended principles outlined in the manual will aid field personnel in coping with most types of damage experienced

in normal operation, and will enable them to keep their airplanes in top repair.

Included in the Structural Repair Manual are sections containing extensive information on fasteners, roll-formed sections, and extrusions. A number of the other subjects that are thoroughly covered are sheet metal forming, heat treatment, protective coatings, honeycomb repairs, corrosion control, and sealants.

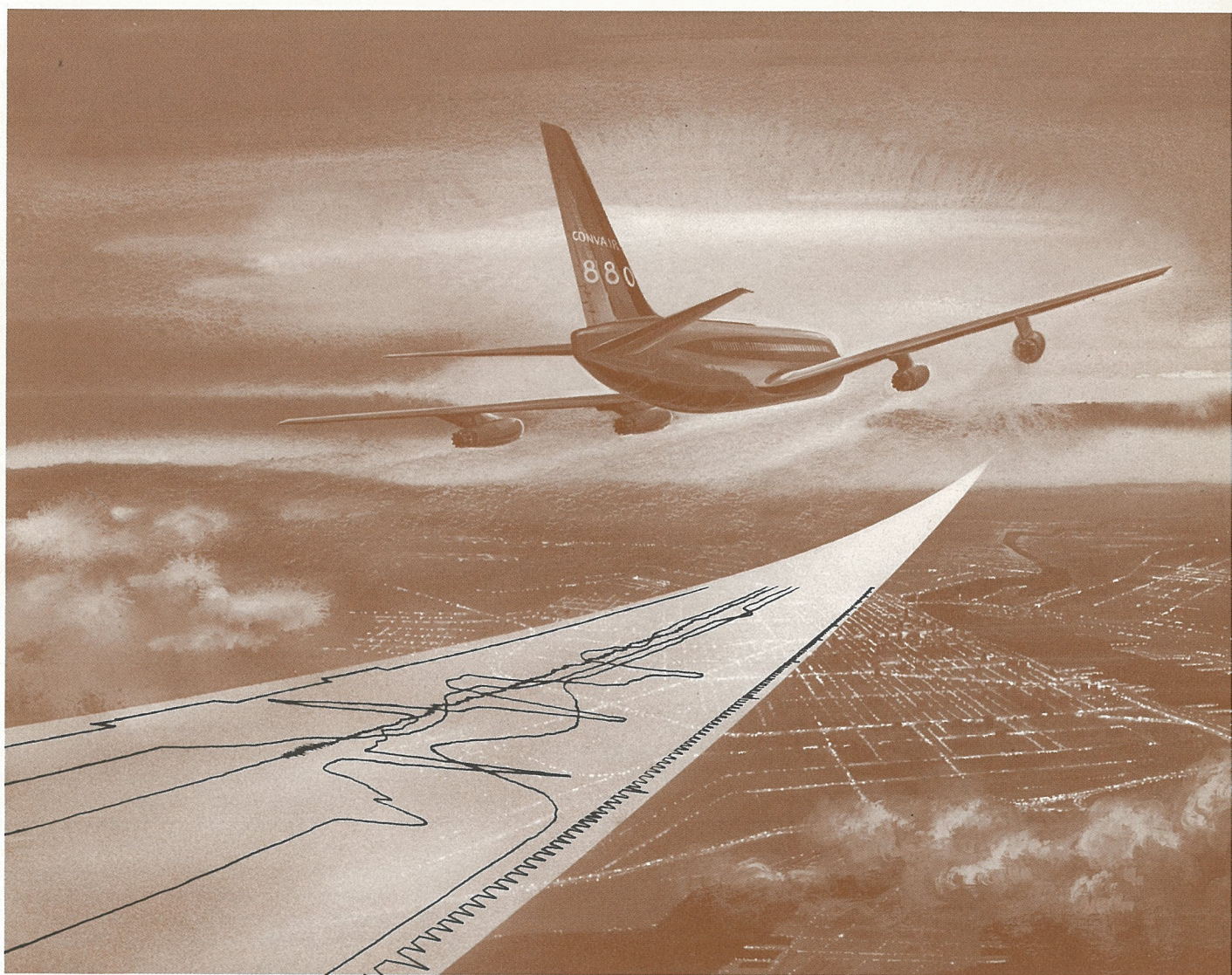
From time to time, as actual repairs are improved upon in the field, and additional techniques are developed through service experience, revisions to the Structural Repair Manual will be distributed to Convair 880 and 600 operators. In this manner, the manual will be kept up to date and one operator will benefit from the experience of another.

The Convair 880 and 600 Structural Repair Manuals are produced in conformance with the ATA (Air Transport Association of America) Specification Number 100. This specification is the accepted standard for manual format throughout the air transport industry, and enables operators using similar but varied equipment to consolidate and thereby expedite their reference material.



VOLUME XII NUMBER 9 JANUARY 1961

Convair Traveler



In this Issue: Flight Data Recorders

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VOLUME XII NUMBER 9 JANUARY 1961

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CHIEF, SERVICE PUBLICATIONS — H. R. KENNEDY
EDITOR — GERTRUDE S. HUNTER
ART EDITOR — N. J. RUTHERFORD

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A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

OUR COVER

The Convair 880 is writing history — its own. Second by second, it sets down its speed, altitude, heading, and up-and-down motions, for perusal later by its owners and any interested official regulatory bodies. The design is by Norm Harrington, cover by Jack Davis.

Beginning with this issue, the Convair 600 will be redesignated as the Convair 990. The intercontinental version will be the 990 Coronado.

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Flight Data Recorders

... Taped records supply second-by-second account of every "880" flight ...

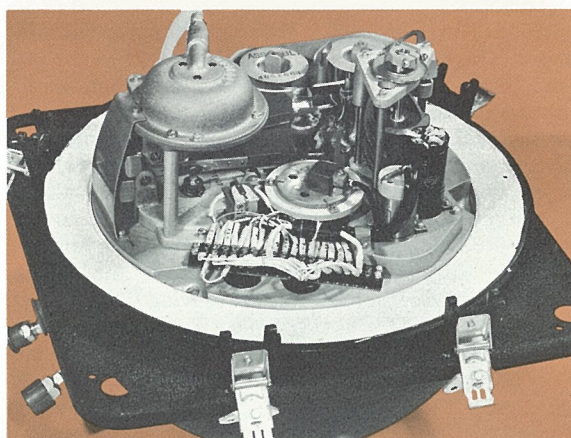
All commercial aircraft certificated to fly above 25,000 feet are required by the FAA to be equipped with a device that automatically records certain flight data. Soon, all turbine-powered aircraft (including turbo-props) weighing more than 12,500 pounds gross will be so equipped. The basic requirements are set forth in Technical Standard Order FAA TSO-C51: the device must record continuously from takeoff through landing — or at least once a second — the altitude, indicated airspeed, compass heading, and vertical acceleration; and the record must be capable of surviving a crash and fire.

Specifically, with respect to the latter requirement, the instrument must preserve its record intact after an impact of 100 g's; after submersion in salt water for 36 hours; and after subjection to heat of 1100°C (2012°F) for 15 or 30 minutes (depending on type of heat) applied over half the exterior surface.

Obviously, the regulation is officially concerned with the causes of disaster. Airline operators, however, are finding another aspect of interest — the second-by-second records of more or less normal flights. Even the minimal data required may be valuable in evaluation of high gust loads or landing shock in their effects on structures. Also, since the recording apparatus must be provided, it can be designed for expansion to keep records other than those demanded by regulation.

General specifications for two types of recorders, oscillographic and magnetic tape, have been drawn up by ARINC (Aeronautical Radio, Inc., an association of manufacturers and operators that sets standards recognized by the trade). The term "tape recorder" is, of course, familiar; "oscillographic" merely describes the common type of chart used in seismographs or furnace heat records, for example, in which a line is continuously drawn on a graph to represent amplitude of earth tremors or temperature vs time.

The LAS (Lockheed Air Service) recorder, flying on many "880" aircraft today, is designed primarily to meet minimum FAA requirements, and is relatively simple. It is housed in a split spherical shell, mounted in the hydraulic compartment or on structure just aft of the forward cargo compartment. Altitude, airspeed,



Spherical shock-proof, fireproof shell houses LAS recorder. It is mounted near airplane CG.

and vertical acceleration sensors are all within the unit, each mechanically linked to a stylus. A fourth stylus is positioned by a synchro, driven by the transmitter in a compass indicator. Altitude and airspeed sensors are connected to the copilot's pitot and static systems.

In the standard Convair installation, the recorder begins operating when external electrical power is disconnected after engine start. The recording medium is aluminum foil. The three styli for heading, altitude, and airspeed utilize the full width of the foil, so that the recording lines may cross each other. The compass heading is calibrated to 180°, rather than 360°, doubling the resolution factor. A binary (on-off) coding indicates which half of the azimuth the heading is on; a stylus contacts the foil to make a straight line for the "on" phase, and lifts for the "off" phase. To read the record, a transparent overlay, bearing the calibration, is placed over the graph. Along one edge are 1- and 15-minute time markers. Digital information, such as flight number and date, can be added by optional coder.

The spool holds 100 feet of foil, enough for approximately 150 hours of operation. The foil is pulled past the styli at a steady rate by an escapement mechanism. The motor that drives the escapement operates through a spring, so that recording of all parameters except heading continues for ten minutes after power is cut off. A small microphone in the unit is connected to the airplane intercommunications system; by listening for the sound of the escapement, the crew can check that the recorder is operating. In one installation, a signal generator is substituted for the microphone.

In addition to "crash recorders," two "880" aircraft are now carrying NASA VGH units which record essentially the same data. The VGH (Velocity, Gravity, Height) records are for collection of operating statistics, relative to gust loadings. The units are supplied by NASA (National Aeronautics and Space Administration), and the records are returned to NASA for processing.

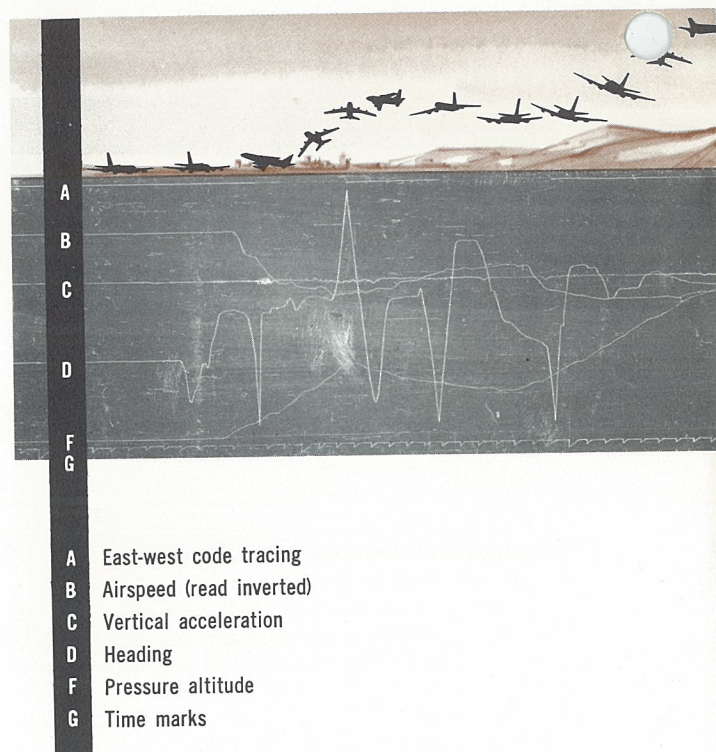
This unit is interesting because of its method of recording. The medium is a 70mm strip of photographic paper. The two pressure-sensitive elements — the synchro from a remote-mounted accelerometer, and a timer — actuate mirrors that reflect a lamp image through a 0.003-inch slit across the recording medium. The record resembles that of the LAS recorder, with a high degree of resolution for accuracy.

A somewhat more complex oscillographic recorder, meeting TSO-C51 and ARINC requirements, but with capability for expanded utility, is made by the Technical Products Division of the Waste King Corporation. This unit is sized for mounting in the ARINC standard ATR rack, and will normally be mounted in the electronics compartment. One component, the accelerometer, must be mounted near the airplane center of gravity without shock mounts; it is supplied as a separate unit. Airspeed and altitude sensors operate their styli mechanically. Heading and acceleration sensors are linked to the styli through synchros.

In this recorder, the medium is stainless steel foil with a black high-temperature-resistant coating, approximately 5 inches wide and 150 feet long. It is divided into four strips for the required four parameters. The stylus tracings do not cross each other; the calibration can therefore be scribed on the foil surface. The tracings are made by diamond scribes on the styli, which are pressed down periodically to cut through the foil coating, leaving a bright line 0.002 inch wide. The foil moves at the rate of six inches per hour. Since the scratches are made at half-second intervals, the typical tracing appears as a solid line, thin enough to be read with the required accuracy, even though the calibration band width is comparatively narrow.

The foil for this unit is coated on both sides. It can be turned over and run through again, doubling the time of recording per spool (from 300 to 600 hours); with proper readout equipment, it can be used for double scribing on both sides, thus allowing 1200 hours of operation per spool.

The styli are recording only 20 percent of the half-second interval, and float the rest of the time. Since



This is LAS record of an actual flight. "880" took off at San Diego to west; climbed toward west; turned east and leveled off; made S turn back toward west; resumed course and climbed to cruise altitude; flew east to El Paso; circled field to left and landed toward southeast.

vertical accelerations, as from gusts or landing, are of brief duration, the acceleration recording circuit requires a half-second memory in order to record peak impulse during the interval.

As in the LAS record, the heading calibration is for 180° of azimuth. The binary indicator for heading is a continuous line alongside the azimuth strip. The scribe is moved by a solenoid laterally across the surface, somewhat less than 1/4 inch, to show on-off coding. Along one edge of the medium is a trip-and-date line. This is an event type binary recorder, driven by an encoder that can be manually set to record a succession of six numbers as a series of pulses. The encoder is remote-mounted, usually in the flight compartment.

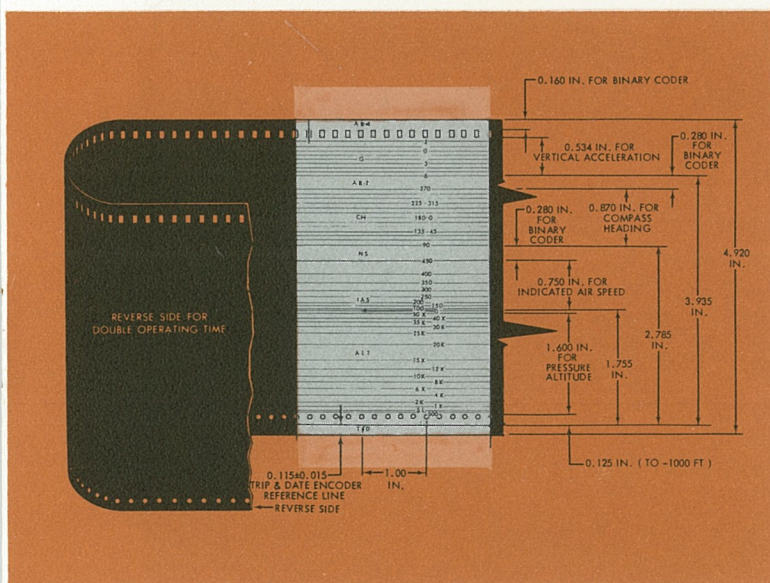
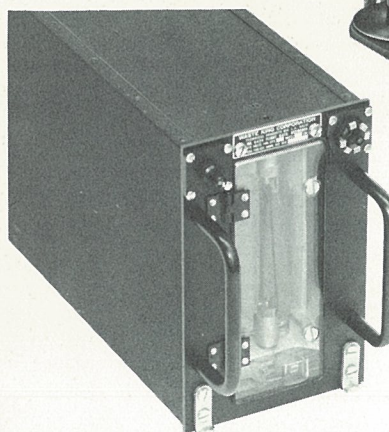
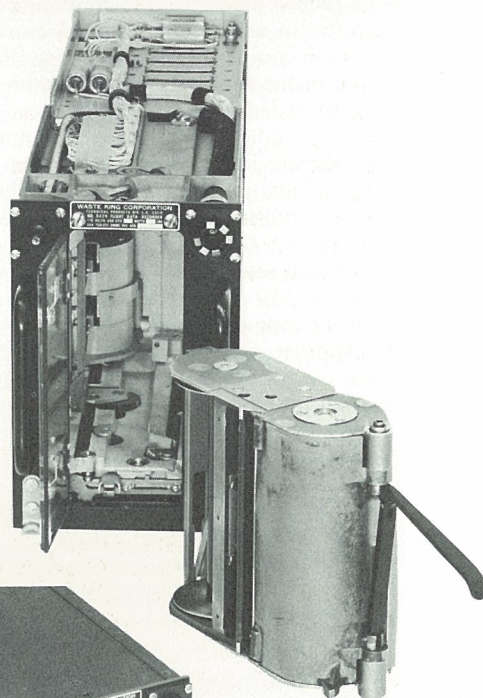
Two other binary scribes are provided for the operator's use. Since a binary record gives only a "yes" or "no" answer, these records are most useful for showing the length of time a certain condition holds. For example, if tied in with a cabin air pressure transducer, the binary line could record precisely how long the pressure remains at sea level; but recording of the actual pressure would be limited to sampling at intervals. In computer language, recording is at the rate of



only one bit per half second; recording a pressure would require converting the analog quantity to digital, encoding it, and then recording the code, probably over a time period of several minutes.

The evident advantage of the oscillographic record is that it is visible, immediately available, and storable as is, for as long as desired. The record has such a fine degree of accuracy that machinists' microscopes or projection devices are needed for the best readings possible.

By comparison, tape recorders have two disadvantages: 1) it is more difficult to preserve the record intact in a crash, and 2) the tape must be "played back" in some manner over special equipment for interpretation. On the other hand, tape recorders have potentialities for elaboration of the record. The ad-



Waste King record is on coated steel foil. Main unit, right, is sized for standard shelf mounting.

vantages are that the speed of recording is subject to electrical limitations rather than mechanical — that is, measurable in milliseconds rather than seconds; that a great deal of data can be recorded on small physical areas; and that the information, being already in electrical form, can be fed directly to electro-mechanical and electronic computers and data processors.

A brief description of the AG-8 flight performance recorder, now being offered by Minneapolis-Honeywell Regulator Co., will serve to illustrate the speed of recording and the elaboration of the record. In this installation, electronic circuits, heading synchro, time clock, and pressure transducers are in one package, and the recording heads and tape in another. Both units are ATR-sized for electronic compartment mounting. The tape unit has shock and thermal protective materials. The vertical acceleration sensor is remotely mounted near airplane CG.

The tape record is digital, in pulse-train form. Number of pulses is directly proportional to input signal amplitude. If reproduced graphically, the pulse train would resemble that of the event-type binary previously described; but, where a scribe may require minutes to record a train of pulses legibly, the tape can record many each second. The transducer signals are fed to an analog-to-digital converter, and thence through comparators and gates to the recording heads. Each of the four parameters is sampled once a second and recorded on a separate channel. Another channel records audio signals. The air crew can address the recorder to identify date and flight number, and also to add data, at any time, about flight plans or unusual flight conditions. This channel is also intended to be tied in with the flight deck warning circuits, to record alarms in audio tone signals. Recording time on the spool is 150 hours; the recording can then be erased and the tape used again.

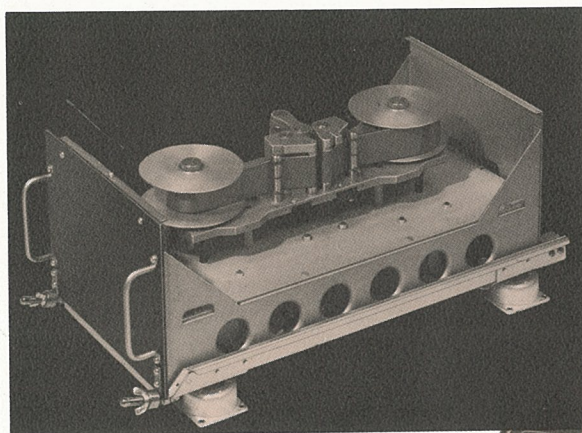
Another channel is available for operations analysis. On this, data can be multiplexed. Using the same one-second recording time, as many as 60 different

readings can be taken once a minute and recorded sequentially. This one channel can add a very large expansion of function for the recorder.

From the operator's view, the information most often desired is that relating to operating procedures and wear and fatigue factors. Engine tail pipe temperature, rpm, and pressure ratio are typical of the useful parameters. Vibration pickups on engines and control surfaces may yield useful data. System pressures and temperatures — hydraulic, fuel, lubrication, air conditioning — can be monitored. Even strain gages can be monitored, if desired.

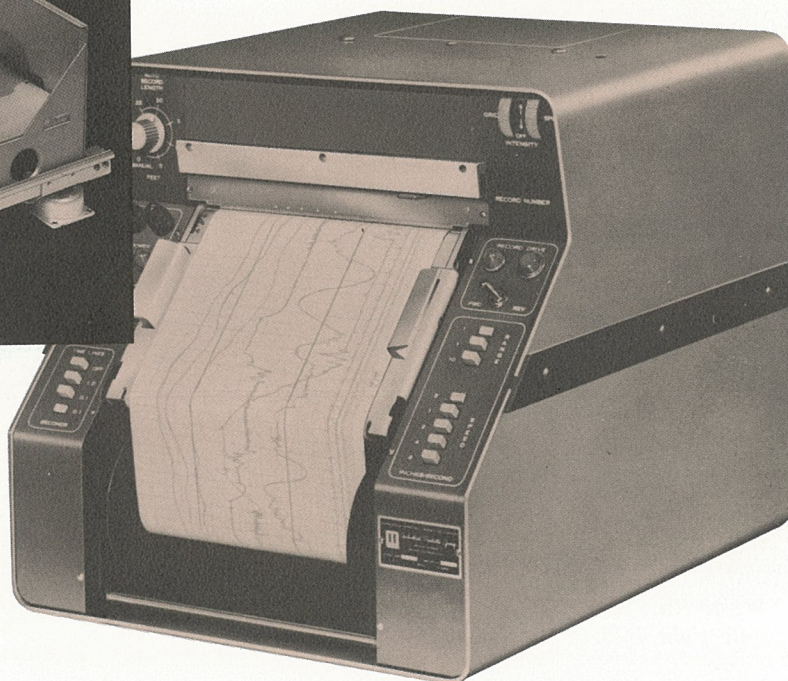
The data can be read out in several ways. The digital signals can be reconverted to analog and fed to an instrument panel comparable to that on the airplane, or used to operate an oscillographic recorder. The signals can be fed directly, without reconversion to analog, into standard digital counters which print out records in tabular form. They can also be fed to a computer translator for digital computer processing. For making permanent records, either on tape or graph, the tapes can be edited to take out the long-term steady-state portions of the flight that are of no particular interest.

Even more versatile tape recorders are coming on the market. Some record frequency modulation rather than pulse trains, thereby greatly increasing the analog capacity of a single magnetic track. Highly sophisticated recorders and associated ground processing systems are presently being utilized in flight test programs and missile telemetry. The next few years will probably see more commercial adaptations of such systems to monitor flights for guidance in maintenance.



Tape in Minneapolis-Honeywell unit, above, is fed from another unit containing sensors, clock, and synchro.

One method of readout is by making oscillographic record (right). Tape may be fed directly into computers.



Convair 880/990 Oxygen System

... high pressure oxygen is immediately available in an emergency ...

Convair 880/990 jet airliners have pressurized cabins that do not usually require supplemental oxygen. But, as protection for the flight crew and passengers in case of emergency, the aircraft is equipped with a high-pressure, 1800-psi gaseous oxygen system. In the event of rapid decompression, oxygen is immediately available for all occupants of the airplane.

From an altitude of 41,000 feet, the Convair 880/990 airliners can descend to an altitude of 17,000 feet in three minutes. At 17,000 feet altitude, the flight crew and passengers have available continuous oxygen for a period of 15 minutes; at an altitude of 14,000 feet, the flight crew has oxygen available for one hour and 45 minutes, and there is sufficient oxygen for 10 percent of the passengers for a duration of 30 minutes. One member of the flight crew is on oxygen at all times above an altitude of 25,000 feet.

The main oxygen supply storage cylinders are installed on the left side of the flight compartment, aft of the pilot's console. The cylinders have a capacity of 74 or 107 cubic feet, and weigh approximately 33 or 44.8 pounds, respectively, depending on customer requirements. Each is charged to 1800 psig.

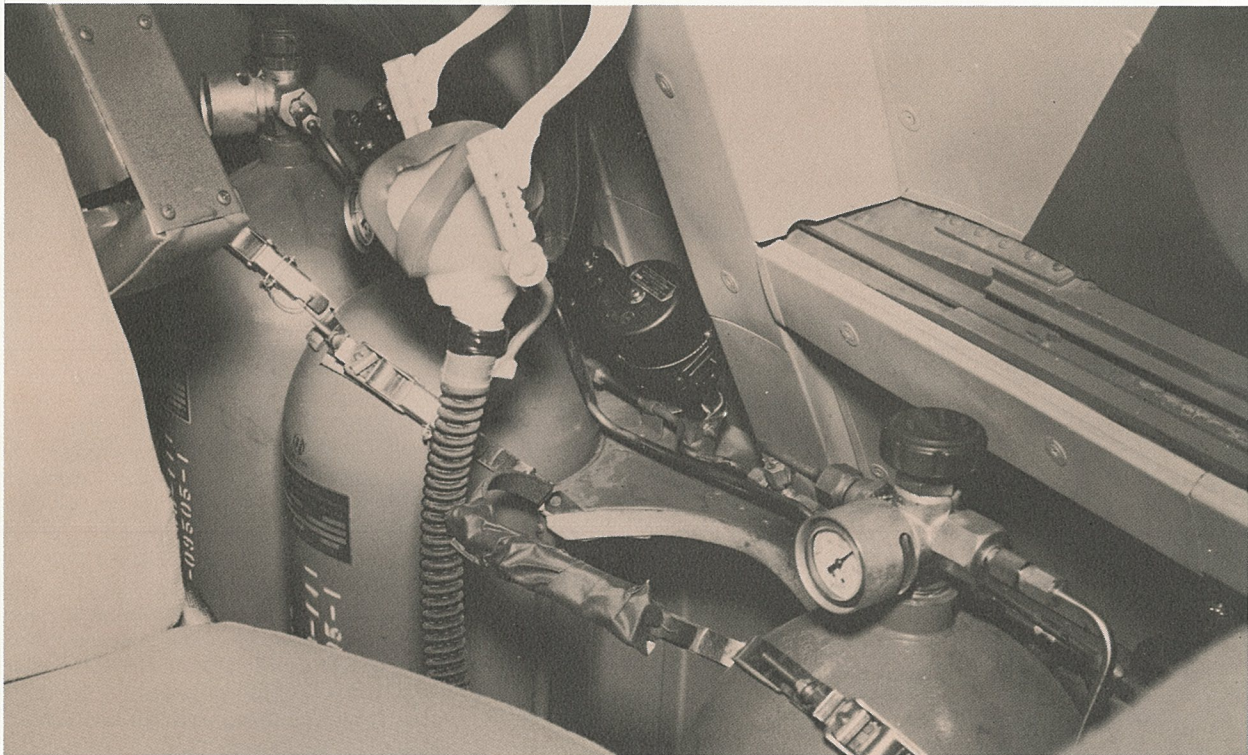
The cylinders are equipped with slow-opening valves to prevent pressure surges in the system. A safety disc, built into each valve, is designed to rupture at a pressure of 2800 to 3000 psig. In the event

that a safety disc should blow out, the entire contents of the cylinder will dump overboard, ejecting a green blowout disc. The green disc is normally visible from outside the airplane; if the disc is not visible, it is an indication that at least one oxygen cylinder has discharged overboard. A gage, which is an integral part of each cylinder valve, is mounted on the upstream side of the valve, indicating the contents of the cylinder.

The flight crew is normally served by the forward cylinder; the passenger compartment by the aft cylinders. The flight crew and passenger systems are connected by a high-pressure line valve that can be opened to enable the flight crew to draw on the passenger oxygen supply, should the necessity arise.

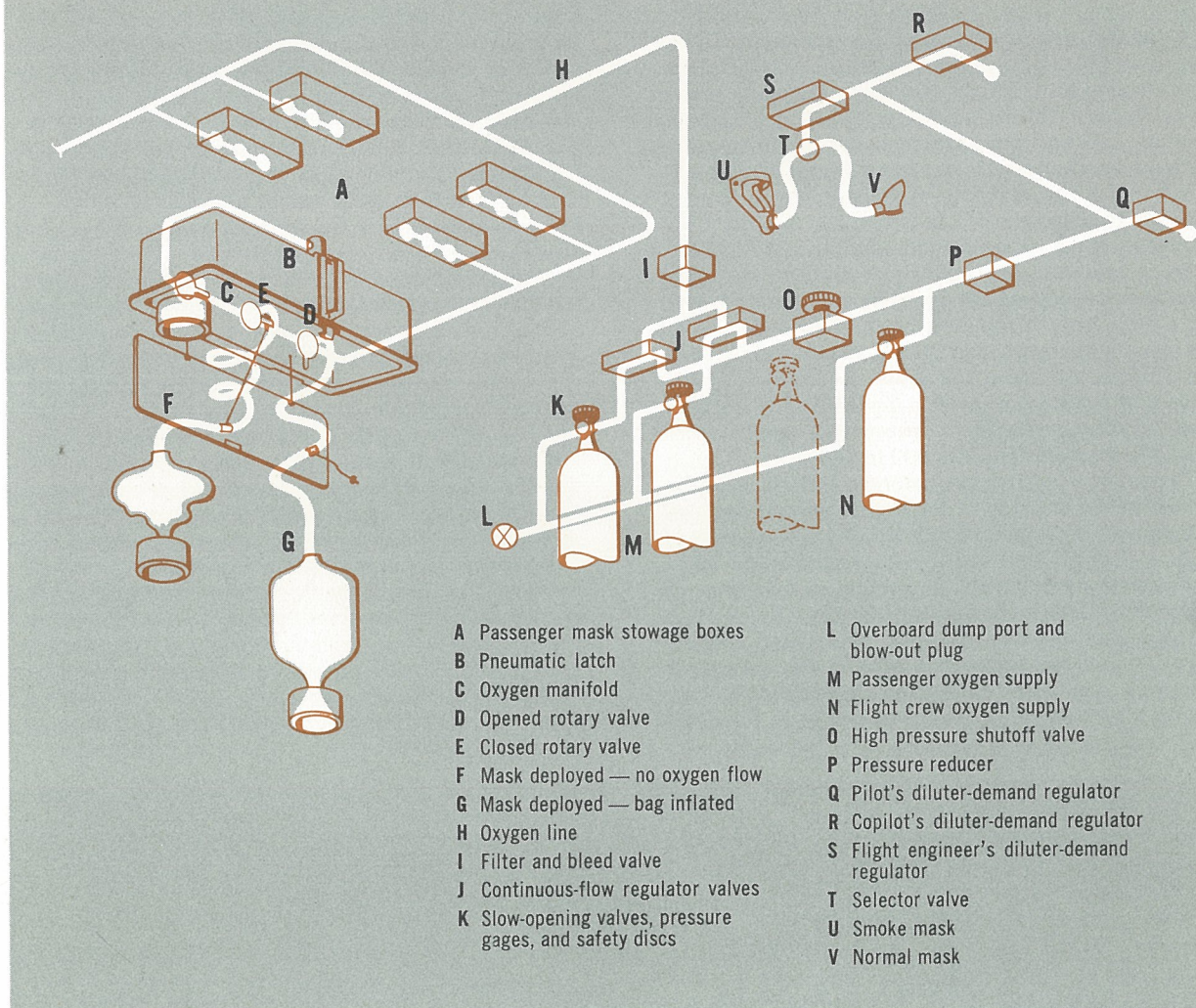
The pilots and flight engineer are supplied with a diluter-demand type oxygen system, permitting individual crew members to manually select either diluted or 100 percent oxygen. The system is capable of continuous operation up to 35,000 feet, and limited operation at an airplane altitude to 41,000 feet.

Each location in the flight compartment (with the exception of the observer's position on some versions) is equipped with a regulator; a half-face oxygen mask; goggles, or a full-face smoke mask; and a mask selector valve. On those aircraft that have a third pilot's position, a half-face oxygen mask, a pair of smoke



Main oxygen cylinders in "880" with provisions for fourth cylinder. Mask shown serves third pilot.

TYPICAL OXYGEN SYSTEM SCHEMATIC



goggles (instead of a smoke mask), and a mask plug-in connector assembly (in lieu of a mask selector valve) are supplied. On some versions, the flight engineer's station contains this same equipment.

Visual indication that oxygen is flowing through the regulator with each inhalation is shown by a flow indicator on the regulator.

A pressure reducer, installed in the supply line between the oxygen storage cylinder and the flight crew diluter-demand regulators, decreases the oxygen pressure from 1800 psig bottle pressure to 50-75 psig operating pressure.

The passengers, cabin attendants, and observer are served by a continuous-flow type system which operates automatically when the cabin pressure altitude exceeds 14,500 (± 500) feet. When the system is automatically actuated, cup-type oxygen masks are released from an overhead panel, dropping a mask to hang approximately 11 inches in front of each pas-

senger, cabin attendant, and observer position. A lanyard is attached to a plastic supply tube just above a reservoir bag, and hence to a clip on an actuating lever. A pull on the suspended mask turns a rotary-type lever down, opening the supply valve and allowing the lanyard to slip from the lever, further releasing the oxygen mask to a full 48 inches (72 inches on attendants' and lavatory masks) from the overhead compartment. With the supply valve open, oxygen enters the reservoir bag through perforations in the supply tube within the bag, and the mask is ready for use.

The compensated safety-dilution valve automatically permits cabin air and oxygen from the reservoir bag to be inhaled together. The reservoir bag, inhalation valve, and safety-dilution valve enable the passenger to inhale the proper air-oxygen mixture deeply without collapsing the face mask. During exhalation, the exhalation valve opens directly to cabin air. The

oxygen required for a cabin altitude of 10,000 to 41,000 feet varies from approximately 13 psig to 50 psig, being programmed by an aneroid-controlled automatic regulator.

Manual override levers on the automatic regulators may be actuated to provide regulated oxygen for the passengers at altitudes below the cabin automatic opening altitude.

The Convair 880 passenger system has the following mask locations in the main passenger cabin area: three masks in each of the convenience pod compartments (overhead panels), located in the hattracks directly above the passenger seats; two masks in each double storage compartment above the lounge seats; and two single masks in stowage boxes located in the aisle overhead trim panel in the center of the lounge (except those versions that have no lounge provisions). Additional mask positions in the cabin area are: two masks located in the ceiling of each lavatory; three single masks for the use of cabin attendants — one mask in the forward entrance area (some versions have a double-mask stowage box for the forward cabin attendant); and two masks in the aft entrance areas. Some configurations have a passenger-type mask installed in the flight compartment for the use of an observer.

The passenger oxygen mask is made of soft plastic, approximately four inches in diameter and three inches deep. It is formed like a cup to fit over the user's mouth and nose. It is reusable after sterilization. Attached to the mask is an elastic head band, an inhalation valve, an exhalation valve, a compensated safety and dilution valve, and a plastic reservoir bag with plastic supply tubing. An instruction illustration is printed on both sides of the reservoir bag.

To stow the masks after use, the stowage compartment door mechanism must first be cocked by pulling the door lock to the right against the spring until the bellcrank and holding arm are in the cocked position.

Before the oxygen mask assembly is stowed, it is prepared in a manner that will allow it to fall free when the oxygen system is activated. The supply tubing is coiled into three or four four-inch diameter

loops, permitting the mask to hang approximately 18 inches below the coil. The lanyard is then wrapped once around the coil, and the plug on the free end of the lanyard is inserted into the clip on the supply valve lever. The valve lever is then rotated to the closed position.

When all of the masks of one container are coiled and clipped, and all of the rotary valve levers are up in the closed position, the reservoir bag of each mask is wrapped around the head band and the resultant roll coiled around the top of the mask. The masks are then positioned in the stowage compartment so that the faces of the masks rest squarely on the inside surface of the compartment door.

Care must be taken when stowing the masks to prevent reservoir bags and tubing from becoming lodged between the masks and the compartment sides. After closing the stowage compartment door, the door latching mechanism must be checked for positive locking. (See page 10 for oxygen mask stowage details.)

First-aid oxygen for passengers and a supplemental portable supply for cabin attendants and flight crew is provided by several portable oxygen cylinders that are located in the passenger compartment and in the flight compartment. The flight crew portable cylinder is equipped with a full-face mask for protection against toxic conditions. The portable oxygen cylinders in the passenger compartment have two types of breathing equipment, depending on customer's requirements. One type of equipment consists of both demand and continuous flow regulators, full-face masks connected to 100-percent-oxygen demand regulators, and rebreather disposable masks provided for four-liter-per-minute (continuous) flow bibs. The second type of equipment consists of continuous-flow regulators having four-liter-per-minute flow bibs and two-liter-per-minute flow bibs. Each portable oxygen cylinder is equipped with two or more rebreather disposable masks. Placing the control handle in the ON position renders either type of portable oxygen system ready for use.

The flight compartment portable oxygen cylinders have a capacity of 310 liters (11 cubic feet), and the passenger compartment portable oxygen cylinders have a capacity of either 203 liters (7.15 cubic feet) or 310 liters, depending on customer's requirements.

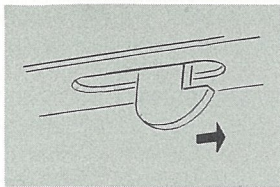
To assure safe, dependable operation of the oxygen system, extreme care must be exercised during assembly, installation, and inspection of the system. The following set of rules must be strictly observed:

1. Prior to working on the oxygen system, be sure that hands, tools, and clothing are free of grease or oil contaminants. No oil or grease substances shall be permitted on any part of the oxygen system.
2. When oxygen is being used for purging or for functional testing, open all cabin compartment doors and flight compartment windows to dissipate the enriched atmosphere of oxygen and air.
3. Do not smoke in the vicinity of any oxygen testing or purging procedures.
4. Do not loosen or tighten line fittings until all pressure has been bled from the system.

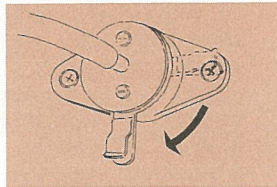


Passenger oxygen masks release automatically when needed. Model demonstrates functional use of mask.

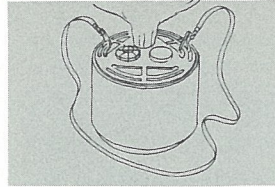
Passenger Oxygen Mask Stowage



1. Pull hook in direction of arrow to cock door latch mechanism.



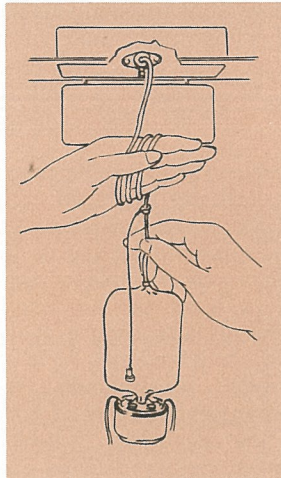
2. Rotate actuating lever on rotary valves to down (open) position.



3. Relocate head band clips to inner mask ring.

CAUTION:

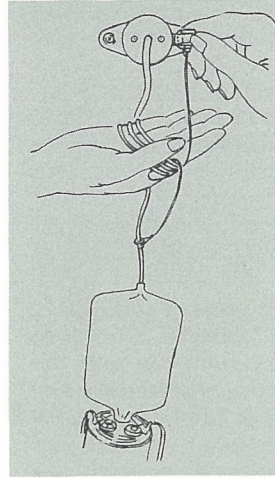
PRIOR TO WORKING ON OXYGEN SYSTEM, SAFETY AND PRODUCT APPEARANCE DEMAND THAT HANDS, TOOLS, AND CLOTHING ARE FREE OF GREASE OR OIL CONTAMINANTS.



4. Grasp mask supply tube in left hand, about level with lower edge of open stowage box door.

5. With right hand, coil supply tube around left hand. Form 3 or 4 loops approx. 3.5 inches in diameter.

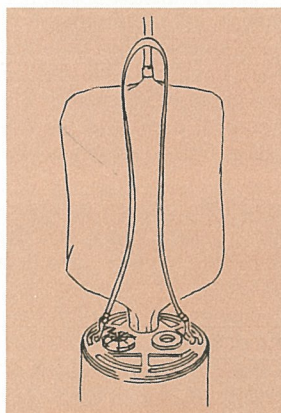
6. Rotate left hand (holding coiled supply tube) to palm-up position.



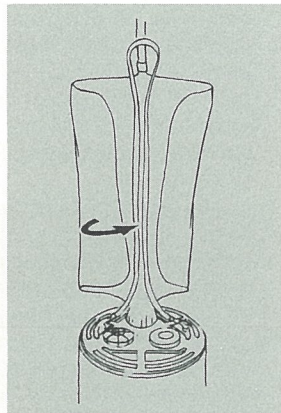
7. With right hand, grasp lanyard (attached to supply tube at yellow ferrule) and wrap lanyard around coils.

8. Push plug on end of lanyard into clip at end of rotary valve lever.

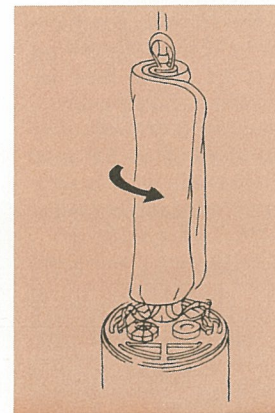
9. Rotate actuating lever on rotary valve to up (closed) position.



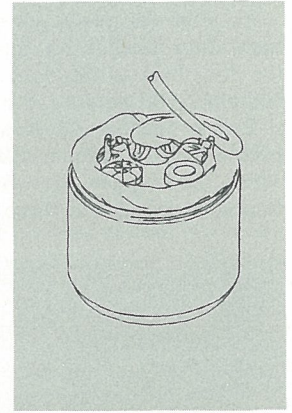
10. Smooth plastic reservoir bag. Place elastic head band in middle of bag.



11. Fold reservoir bag in half, around head band.



12. Roll folded bag from center to edge.



13. Starting with the most remote mask, coil rolled reservoir bag and supply tube hanging from the yellow lanyard ferrule.

14. Push mask and tubing straight up into box. Make certain that neither a part of bag nor tubing becomes lodged between mask and side of box. Any binding or lodging may prevent mask from falling free when stowage box is opened.

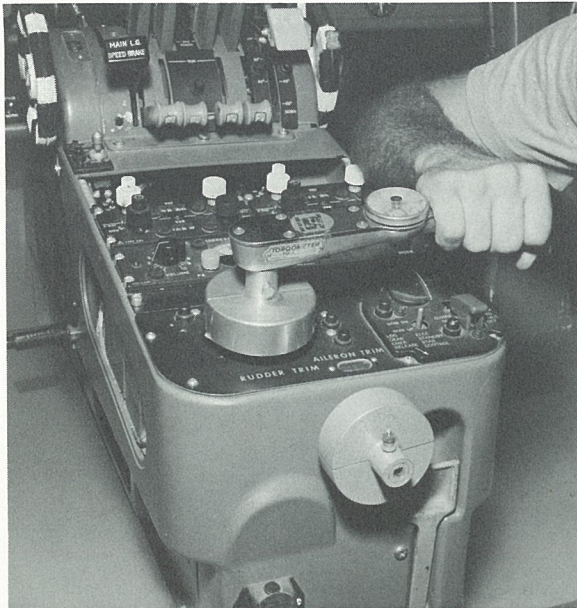
15. While holding stowed masks in box, insert door hooks into their respective slots.

16. Gently jostle door and settle tubing and masks in position (face of mask to be flush with door).

17. Close stowage box door. Ascertain that latches engage.

Trim Wheel Check Tools

A special testing tool is used on the "880" production line to facilitate checking out the rudder, aileron, and stabilizer trim controls from the pedestal in the cockpit. The tool is used for determining degrees of aileron and rudder trim wheel rotation, and for applying and measuring the rotational forces required on the various trim control wheels.



Rudder/aileron trim wheel adaptor (on rudder trim wheel) showing use with torque wrench.

The tool, P/N 22-04304 TSTO, is composed of several parts that are used separately or together, depending upon the test application. These parts are a special protractor (which is used on the aileron and rudder trim wheels), a group of special clamps or adaptors (one for each type of trim wheel), and a calibrated torque wrench. The adaptors clamp over, or attach to, the particular wheel. By applying the torque wrench to the adaptor, torque can be applied to the trim wheel to measure the torque required to operate the trim wheels.

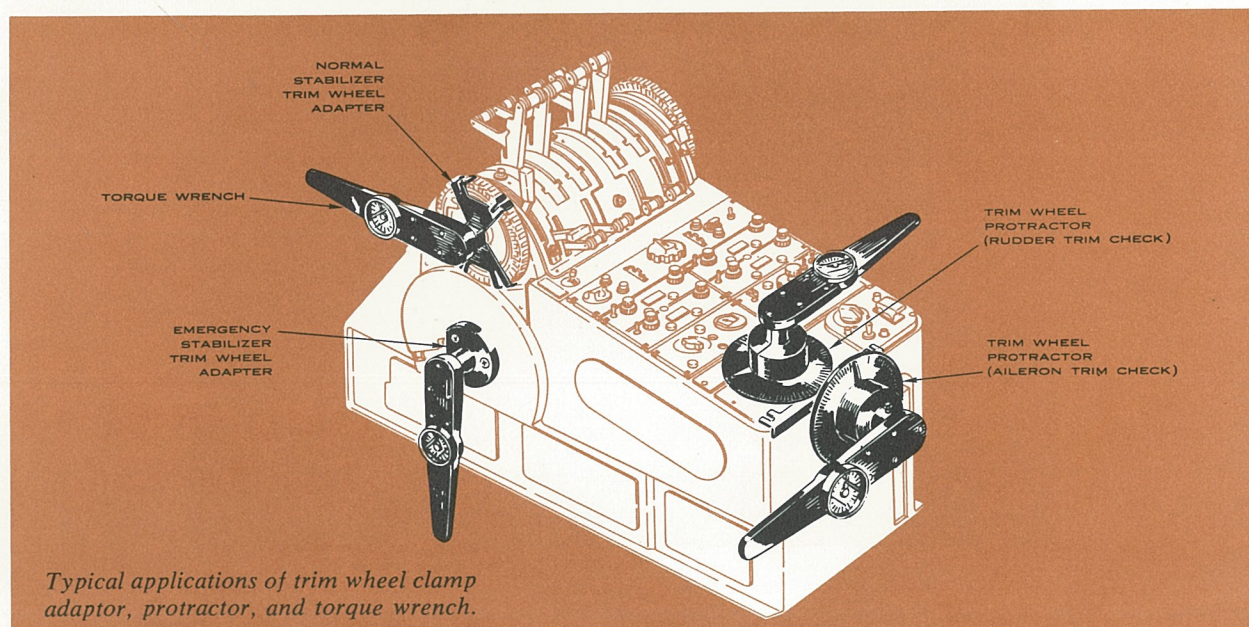
The protractor, used for measuring aileron and rudder trim wheel rotation, is attached to the pedestal behind the wheel. A pointing needle is attached to the wheel with a retaining screw. The dial is adjustable so that the needle can indicate an initial zero position; thus, any rotation of the wheel will move the needle to indicate degrees of rotation.

The clamp adaptor, which is used over the rudder and aileron trim wheels, is a split wheel that fits over the trim wheel and is clamped on with a bolt. The clamp outer hub forms a square socket into which the torque wrench end may be inserted.

The torque wrench adaptor for the stabilizer trim wheel is a similar clamp except that four "fingers" with grooved ends fit over the grooves on the outer rim of the stabilizer trim wheel. A reading of 2.85 inch-pounds on the torque wrench dial is equal to one pound at the trim wheel rim.

The emergency stabilizer trim wheel adaptor is attached to the emergency stabilizer trim wheel by means of three screws (same screw holes as on the wheel). A reading of five inch-pounds on the torque wrench dial is equal to one pound on the emergency stabilizer trim wheel handle.

Drawings are available for local manufacture of the tool.



Typical applications of trim wheel clamp adaptor, protractor, and torque wrench.

Low Temperature Door Tests Convair 880

Convair structures lab engineers recently conducted a series of tests to prove the operating capabilities of the main entrance door of the Convair 880 under varying icing conditions.

A plywood "cold" box, 90 inches high by 60 inches wide, was constructed and formed to fit the contour of the fuselage in the area of the aft main entrance door. The box was placed over the door and the area sealed; CO₂ was pumped in to lower the temperature and freeze the area covered by the box. During some of the tests, water was sprayed into the box, resulting in an approximate 3/16-inch thick coating of ice over the door edges.

Thermocouples were attached to the top and bottom of the door on the outer skin, and to the top of the door on the inside structure. By monitoring the therm-

ocouples, with a temperature controller-indicator, the "weather" inside the box could be varied to simulate different conditions. Strain gauges were fitted to the door handle, and measurements were taken of the force required to open the door.

The results of the tests proved that under severe weather conditions, with outside temperatures far below 0°F, the door of the Convair jet airliner could be opened from the inside.

To insure successful operation of the door under frozen conditions, it is recommended that a low-temperature grease be applied on the slide tube of the door. All-purpose low-temperature grease MIL-G-7421 (Convair Material No. 273445) was determined by the tests to meet proper requirements for "880" door lubrication.



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CONVAIR DIVISION

GENERAL DYNAMICS CORPORATION

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Convair Traveler



In this Issue: Weight and Balance — Convair 880



OUR COVER

Where gravity dictates design, as in an "880" or in Artist Tony Adams' background mobile, things must be made to balance. Engineers may use computers or vector analysis. Tony has other methods; but then, he can work from visible CG's.

Convair Traveler

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TESTING & INSTALLATION
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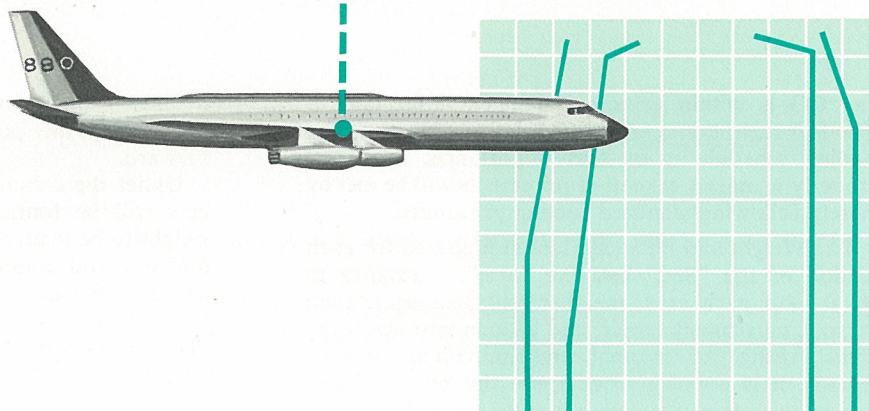
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Weight and Balance

Convair 880

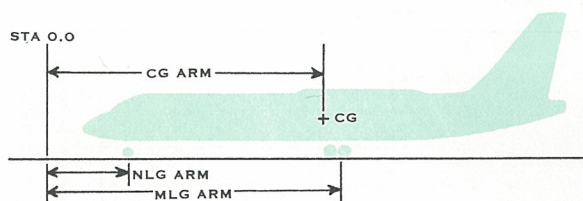


In designing an automobile or an airplane, exact location of the center of gravity must be established. In an automobile, the location is usually of interest to the designer alone; it is a rare motorist who knows where his car's CG is even supposed to be. But in the Convair 880, as in any transport airplane, CG location must be re-established, longitudinally at least, with every major modification to the airframe, re-computed for every flight, and perhaps computed again several times during flight.

The computation is simple in theory, though the arithmetic can be somewhat lengthy. It is based on one aspect of the principle of moments: the gravitational moment of a body about a certain point is the product of the weight of the body times the horizontal distance of the point from the center of gravity. In the "880," the reference point chosen is Fuselage Station 0.0, which is 100 inches forward of the airplane nose. The moment of the "880" about this point is then the airplane weight times the CG station.

With the "880" supported on its landing gear and leveled longitudinally, the airplane moment about Sta 0.0 is also the sum of the moments produced by the weight on the nose gear and the weight on the main gears; that is,

$$\begin{aligned} \text{CG Sta} \times \text{airplane wt} &= (\text{NLG Sta} \times \text{NLG wt}) + (\text{MLG Sta} \times \text{MLG wt}); \\ \text{therefore;} \\ \text{CG Sta} &= \frac{(\text{NLG Sta} \times \text{NLG wt}) + (\text{MLG Sta} \times \text{MLG wt})}{\text{NLG wt} + \text{MLG wt}} \end{aligned}$$



Shortly before an "880" goes into service, CG location is determined by this formula, by actually leveling and weighing the airplane on platform scales, or by use of electronic weighing pads on airplane jacks. Thereafter, a permanent log is kept of all modifications or changes of equipment that affect balance, and the CG station is revised accordingly.

The basic airplane weight, as defined by Civil Air Regulations No. 40, is termed Certified Weight Empty. It might be described as the status of an airplane ready

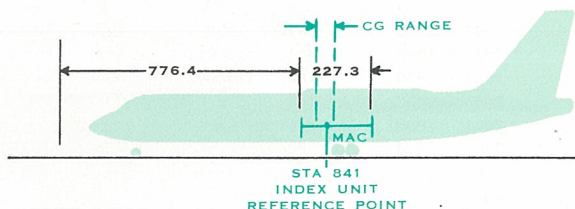
to be loaded for commercial service; it includes all permanently installed equipment, together with undrainable engine oil and unusable fuel, but without "standard operating items." This weight in the "880" is usually 83,000 to 85,000 pounds.

Standard Operating Items are defined as crew and crew baggage; drainable and usable engine oil; passenger service (pillows, blankets, towels, etc.); buffet contents; and water. When these items—usually approximately 2000 pounds—are added to Certified Weight Empty, the airplane is at Basic Operating Weight; that is, ready for fuel, cargo, and passengers.

Basic Operating Weight is the figure with which the ground loading and flight crews will begin. It represents a weight and moment that should vary little from day to day. Passengers, cargo, and fuel are variable factors on each flight. Passenger and cargo, added to basic operating weight, give Zero Fuel Weight. To this is added the fuel load for Ramp Gross Weight, which, less approximately 500 pounds for fuel consumption on the ground, will be the Takeoff Weight.

For flight purposes, CG location is expressed in percent of the mean aerodynamic chord, which, in effect, establishes a relationship between CG and wing center of lift. Since the mean aerodynamic chord of an "880" is 227.3 inches, extending aft from Sta 776.4,

$$\text{CG in \% MAC} = \frac{\text{CG Sta} - 776.4}{227.3} \times 100$$



This percentage must be computed for two purposes: airplane balance limitations are expressed in terms of percent MAC, and so also is the setting for takeoff stabilizer trim. Flight limits are from 16.5% to 34%, varying with gross weight and speed. Stabilizer trim for takeoff will be 6° airplane-nose-up with a forward CG, 4° with a midship CG, and 2° with an aft CG.

Of particular interest is the fact that the "880" will always be within established design limits if the zero

fuel CG is within certain designated limits, and if specified fuel fill and usage sequence is followed. The loading schedule is of first importance; if this is properly managed, takeoff requirements will be met by merely following standard fueling procedure.

The Weight and Balance Manual prepared for each version of the "880" lists the "arm" — distance to Sta 0 — of each crew member and passenger, each cargo compartment center, and all standard operating items. Using the manual and individual airplane records, it is possible to compute the zero fuel CG station to within one hundredth of an inch. This is rarely necessary, and it would involve quite a few figures; the moment of a cup of coffee at the aft buffet is several hundred inch-pounds, and a 130-pound stewardess at her aft station "weighs in" at 165,490 inch-pounds moment.

There are several standard approaches to bring such figures down to more manageable size. Graphs can be used; blocks of passenger seats, or frequently used fuel loads, can be assigned an average moment; for many computations, inch-pounds can be expressed in larger units. Tables can be prepared for recurrent balance problems, enabling the loader to bypass actual computing of moments. All these methods are available and are made use of in the "880" Weight and Balance Manual.

Cargo loadings in forward and aft compartments are used to control airplane balance. The manual provides tables for tabular loading control. Passenger loading is assumed to follow the usual pattern of window seats occupied first, aisle seats next, and center seats (in three abreast seating) last. When the number

of passengers and the cargo tonnage are known, the table gives the proportion of cargo to be loaded forward.

Under the column headings for number of passengers will be found maximum and minimum cargo weight to be loaded in the forward compartment. The maxima and minima take into account the most adverse conditions — whether seats are filled front to back or vice versa, for example, or if there is uneven distribution of buffet contents. With the cargo properly distributed, and the total zero fuel weight within maximum limits, the only concern left is to be sure the fueling procedure is normal.

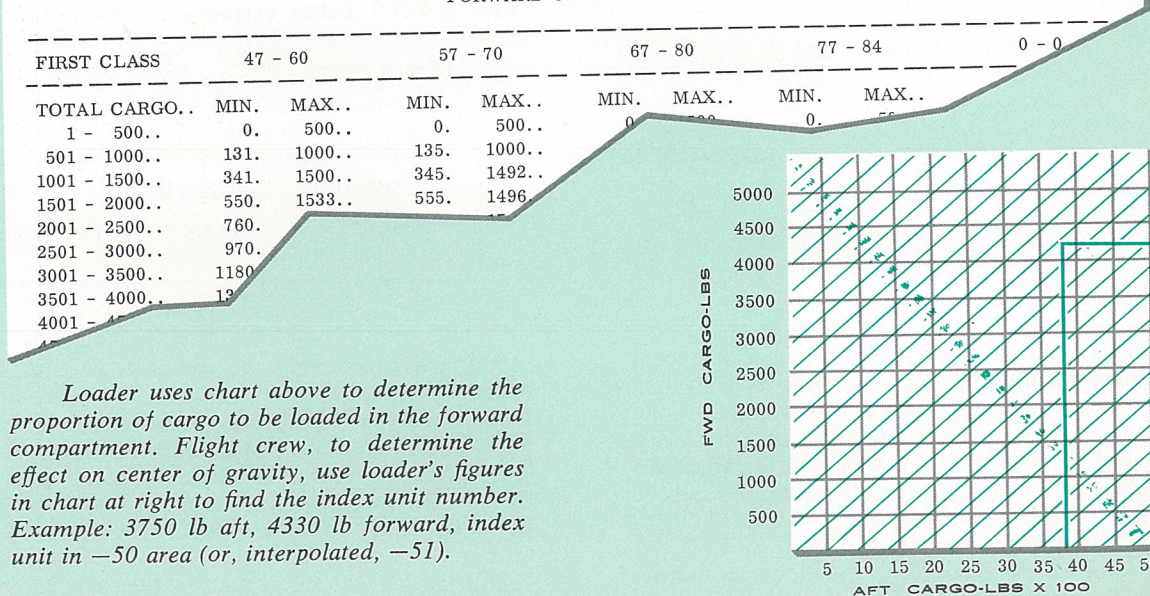
Normal, in this case, means that distribution is maintained approximately equal between outboard and inboard wing tanks until the outboard tanks are full. It is anticipated that the two tanks will often be filled simultaneously with pressure fueling. The only restriction in fueling is not to fill outboard tanks full with the inboard empty. Outboard tanks are considerably aft of CG. Additional adverse factors, such as maintenance personnel all in the rear, could conceivably cause a "tail tipdown." It is immaterial whether one wing is filled before the other; the temporary lateral imbalance need cause no concern.

Even for takeoff, it is not absolutely necessary that fuel quantity be equal between outboard and inboard tanks — only that the CG be within limits. With a full fuel load, there will always be an excess inboard because each inboard tank holds approximately 4000 lb more fuel than the outboard tank. The Weight and Balance Manual contains permissible distribution curves for both takeoff and landing. If fuel loading is found to be uneven, these curves can be consulted to

TABULAR CARGO LOADING CHART

TABULAR LOADING CHART (Cont' d.)

STANDARD SEATING 84 FIRST CLASS PASSENGERS
FORWARD CARGO LOADING



DETERMINATION OF PERCENT MAC AND TAKEOFF STABILIZER TRIM

LOADING FORM

		WEIGHT	INDEX UNITS
WEIGHT EMPTY			
STANDARD OPERATING ITEMS			
CARGO (FWD.) (AFT)			
PASSENGERS (FWD.) (AFT)			
ZERO FUEL WEIGHT			
FUEL		WEIGHT	INDEX
1 & 4 MAIN			
1 & 4 REPLENISH			
2 & 3 MAIN			
2 & 3 REPLENISH			
TOTAL			
RAMP CONDITION			
LESS TRIP FUEL			
LANDING CONDITION			
PER CENT M. A. C. _____		STABILIZER TRIM SETTING _____	

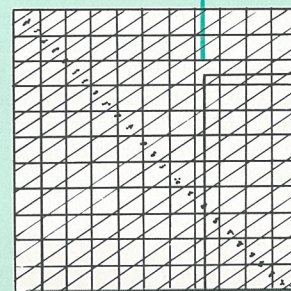
Loading form has column for weight and one for index units.

Weight Empty and Standard Operating Items are taken from airplane Weight and Balance Report.

Cargo weight and index are from cargo loading sheets.

WT INDEX
PASSENGERS (FWD _____) (AFT _____) _____

Index units for passengers are obtained from graph.

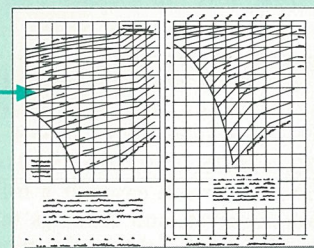


FUEL WT INDEX
1 & 4 MAIN _____
1 & 4 REPLENISH _____
2 & 3 MAIN _____
2 & 3 REPLENISH _____

LOADING (Cont'd.)

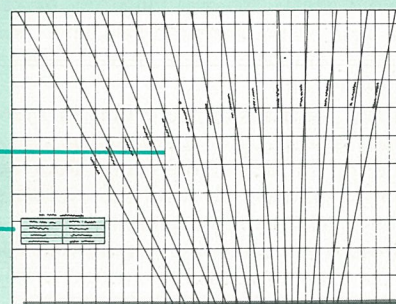
GALLONS	WEIGHT	INBOARD MAIN		INBOARD REPL.		OUTBOARD MAIN		OUTBOARD REPL.	
		ARM	INDEX	ARM	INDEX	ARM	INDEX	ARM	INDEX
75	500	780.0	- 3.1	711.4	- 6.5	849.0	0.4	980.0	7.0
149	1000	782.2	- 5.9	712.3	- 12.9	848.9	0.8	989.2	14.8
224	1500	784.0	- 8.6	713.5	- 19.1	849.0	1.2	995.5	23.2
299	2000	785.6	- 11.1	714.4	- 24.6	849.1	1.6	1000.5	31.8
373	2500	787.2	- 13.5	715.3	- 29.9	849.2	2.0	1003.3	39.2
448	3000	788.5	- 15.8	716.1	- 35.1	849.3	2.4	1005.8	46.5
522	3500	789.8	- 18.0	716.9	- 40.2	849.4	2.8	1008.0	53.8
597	4000	791.0	- 20.2	717.7	- 45.3	849.5	3.2	1010.0	61.0
672	4500	792.2	- 22.4	718.5	- 50.4	849.6	3.6	1011.8	68.2
746	5000	793.4	- 24.6	719.3	- 55.5	849.7	4.0	1013.5	75.5

Indexes are obtained from table. Inboard-Outboard distribution is checked against permissible distribution curves (right).



PERCENT MAC _____
STABILIZER TRIM SETTING _____

Plus and minus index units are added algebraically, and percent MAC is determined from graph. Stabilizer trim setting is given in table at left.



ascertain if distribution is within limits. For en route flight, the Flight Manual recommends that engines be crossed after takeoff until the load is equalized between inboard and outboard tanks, and that fuel be used equally from all tanks thereafter.

For landing, the recommendation is that fuel remaining in inboard replenishing tanks, which are forward of the CG, should be transferred aft to the main tanks. Should transfer not be possible, more fuel should be held outboard to compensate for the forward moment of the inboard replenish tanks. The permissible distribution curves take account of this possibility.

In computing CG in percent MAC for takeoff stabilizer trim setting, the manual makes use of an index system. The index numbers represent, in effect, moments in 10,000-inch-pound increments, related to an arbitrarily chosen CG reference point (Sta 841):

$$\text{Index Unit} = \frac{\text{Weight} \times (\text{Balance Arm} - 841)}{10,000}$$

Tables are used for assigning index numbers to passenger and cargo loads with reference to the portion loaded forward of Sta 841, and to fuel in 500-lb increments to each tank. Forward indexes are minus; aft indexes, plus. These indexes are added algebraically, and CG in percent MAC is determined quickly from a graph.

Leveling and Weighing

Since airplane empty-weight center of gravity may be safely assumed to be on the fuselage centerline, the chief concern in leveling the airplane is to see that the waterline is level longitudinally. There are, literally, half a dozen means provided for telling when an "880" is level. Two require use of an engineer's transit or sight level, two use a spirit level, one a plumb bob, and the other a 50-foot water hose, preferably with transparent end sections.

A row of six brazier-type rivet heads on each side of the fuselage — the only protruding rivets on the "880" skin, incidentally — mark WL 68 at Stations 155.75, 636.75, 650, 916.25, 930, and 1420. Using the transit is much easier if a 6-foot scale is held up against the rivet, and readings taken from the scale, rather than by sighting in directly on the rivets themselves.

On the lower external longeron, or keel, a pair of small drill-mark indentations have been made at WL -2 at Stations 603 and 1036. These can be sighted on directly with a transit.

At Sta 748.8 inside the cabin, an eyebolt has been installed at the top of the fuselage and an indicator on the top surface of the center floor beam. By suspending a plumb bob from the eyebolt, the airplane can be leveled both longitudinally and laterally. An overhead trim panel must be removed, however, and a floor panel taken up to obtain access to this installation.

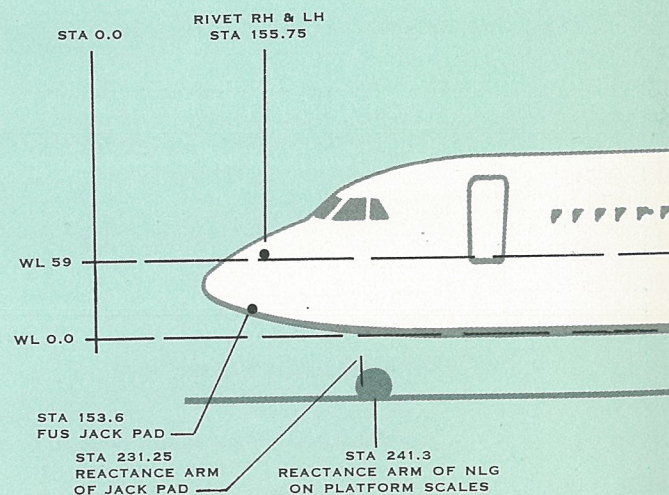
A 24-inch spirit level may be used on leveling lugs installed in the main wheel well, on the forward bulk-

head, and on the left face of the center bulkhead, for lateral and longitudinal leveling. The level may also be held up against the external longeron anywhere between Sta 678 and Sta 832. Between these two points, the longeron lower surface has a constant slope of 0.005 inch per inch; therefore, a spacer 0.100 thick must be used at the forward end of a 20-inch level, or a 0.120-inch spacer with a 24-inch level.

The water hose method can be adapted for "880" use in connection with the drill-marks in the external longeron. A hose is filled with water, and the water levels at the ends of the hose are matched with the drill-marks. Homespun as this method appears, it is highly regarded by Convair engineers. Since the drill-marks are approximately 36 feet apart, the accuracy possible is considerably higher than that with a spirit level; and a water hose is often easier to come by than a transit.

For a comparison indicating possible accuracies of the various methods, it may be noted that the maxi-

LEVELING AND WEIGHING DATA



imum error permissible in leveling is 0.1% MAC. This represents:

- 0° 9' of waterline angle
- 3.3 inches between fore and aft rivets at WL 68 (transit method)
- 0.23 inch at plumb bob zero mark
- 0.05 inch at one end of a 20-inch spirit level
- 1.1 inches between longeron drill-marks (transit or water hose method)

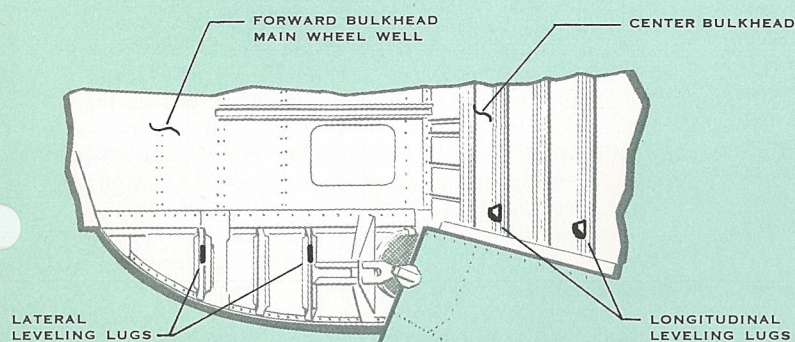
If the "880" is on a level surface with tires inflated normally, and struts deflated, the waterline will be approximately level. It may be seen, therefore, that longitudinal alignment can be adjusted adequately by inflating or deflating the nose strut. This requires only a supply source of compressed air, and can be done after the airplane is on platform scales or on landing gear jacks.

A platform scale under the nose gear should have an area 30 inches wide by 20 inches long and, under each main gear, 40 inches wide by 80 inches long. If

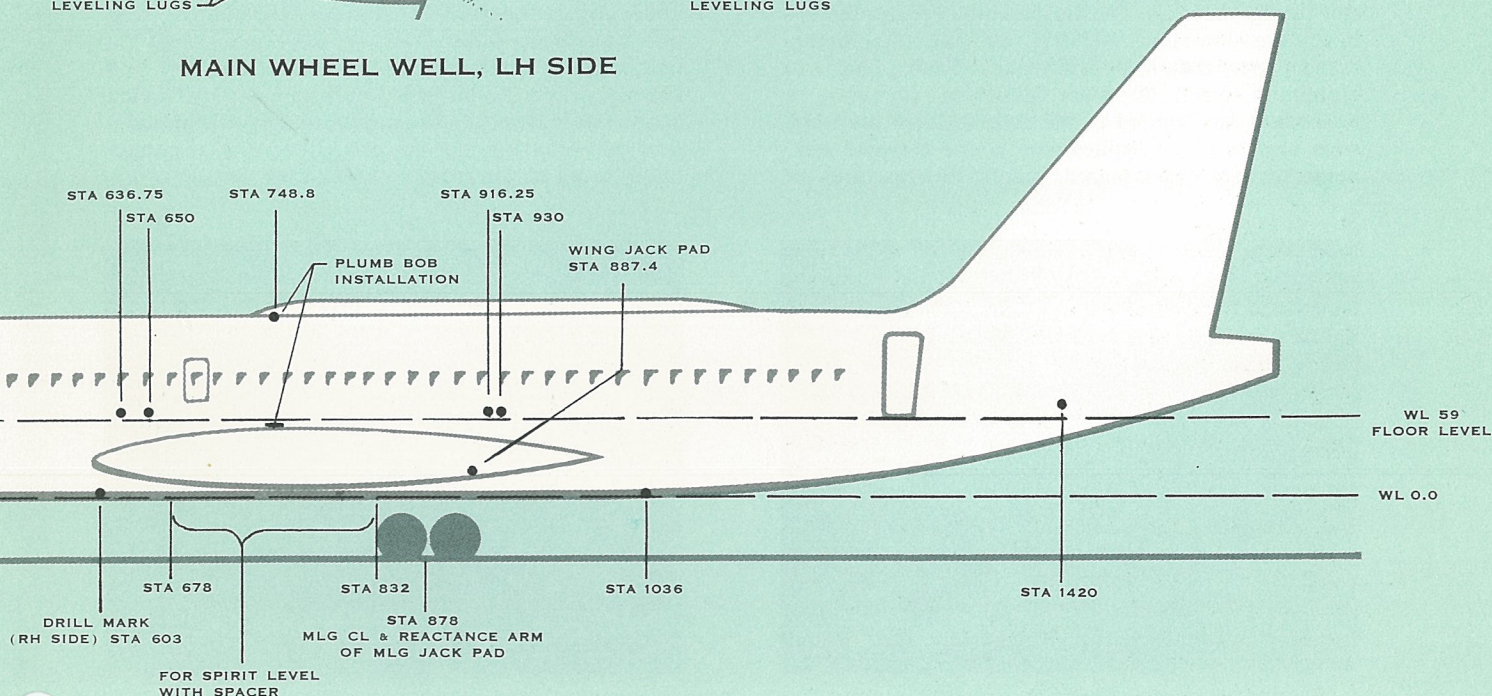
the airplane is to be weighed fully loaded (185,000 maximum), scale capacities should be 20,000 pounds for the nose gear and 100,000 pounds for each main gear. Jack pad permissible loads are 15,000 lb on the nose gear and 86,700 lb at each main gear; this will usually permit weighing at ramp weight, though perhaps not at maximum gross.

If weighing pads are to be used with fuselage and wing jack pad fittings, the maximum weights are 12,000 pounds forward and 66,400 pounds at the wing pads. It is evident that the airplane cannot be weighed at full ramp weight by use of wing jacks; it can be weighed at maximum landing weight (132,800 pounds).

It is sometimes desirable to lower the airplane overhead clearance by raising the nose to lower the vertical fin tip. If the CG is within zero fuel limits and if out-board replenish tank fuel weight is balanced by an equal amount in the inboard replenish tank, the "880" nose wheel can be raised 36 inches without danger of tail tip-down.



MAIN WHEEL WELL, LH SIDE



Honeycomb and Sandwich-Type Construction

Honeycomb sandwich structure constitutes the strongest material in relation to its weight that is known. Borrowing the age-old honeycomb design from nature, and employing modern materials and techniques, man has duplicated the amazing high-strength, lightweight features of honeycomb and applied it to his needs in a multitude of ways.

During the latter part of World War II, honeycomb-cored sandwich components began to appear on military aircraft as non-structural radar housings. Since then the application of honeycomb structures in aircraft, both military and commercial, has grown enormously. Honeycomb sandwich components have proved their structural capabilities in such applications as floors, wing panels, and entire control surfaces. The trend indicates that the application of honeycomb, both structural and non-structural, in ambient and high temperature ranges, is growing steadily.

Convair is making extensive use of the weight-saving honeycomb sandwich structure in the construction of the Convair 880/990 jet airliners. In many cases, this material, besides saving considerable weight, adds greatly to the strength of the part. There are approximately 1100 square feet of honeycomb sandwich structure on the "880" exterior, and 3000 square feet of honeycomb sandwich and foam sandwich structure in the interior. The Convair 990 has approximately 10 percent more exterior honeycomb structural area than does the "880," which indicates the move toward more honeycomb in modern aircraft design.

Manufactured honeycomb is basically a lightweight cellular core, sandwiched and bonded between thin stiff facing materials. The most common core materials in use are aluminum foil, steel foil, and resin-impregnated paper, cotton, and fiberglass. Facing sheets of aluminum, steel, fiberglass laminates, plywood, or hardboard are bonded to the core to form the sandwich structure. In applications where elevated temperatures are encountered, sandwich structures of

brazed stainless steel core and facings are used to withstand the heat.

The strength-weight-rigidity ratio of honeycomb sandwich structure is perhaps its greatest feature. Honeycomb sandwich structure of the same strength rigidity of steel weighs only one-sixteenth that of steel. The weight ratio of honeycomb to aluminum, having the same rigidity, is one-tenth that of steel, and that of honeycomb to plywood is one-fifth.

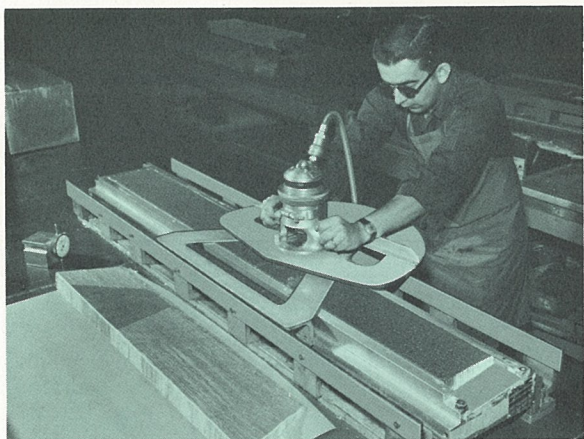
In many applications where sandwich structures are of a decorative rather than a structural nature, plastic foam is used in place of honeycomb core. Flexible polyvinylchloride foam, faced with laminated fiberglass sheets, is used for some of the interior trim panels in the Convair 880/990. Polyurethane foam, faced with Boltaron plastic, forms the sandwich panels underneath the hat racks in the passenger compartment.

Aside from the aircraft interior, honeycomb panels are found on the wing trailing edge, flaps, ailerons, trim tabs, on all control surfaces, and on the elevator trailing edge. The aerodynamic balance boards, spoilers, and foreflaps (eyebrows) are also of honeycomb sandwich structure.

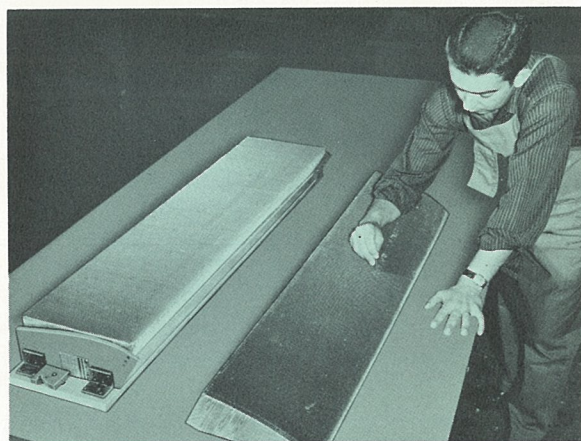
Honeycomb sandwich structures have proved their superiority in resisting sonic fatigue. Their ability to withstand the resonance excited by high frequency jet engine noises has resulted in their extensive application in areas of proximity to jet engine exhausts.

Access doors, microwave windows, and compartment shelves are among the other applications of honeycomb construction used in Convair jet airliners.

The fabrication of honeycomb panels is conducted under closely supervised conditions. Rigid quality control is exercised throughout the entire manufacturing operation — from core cutting to metal bonding. The finished product is inspected ultrasonically by Coinda Scope (stub meter); test coupons undergo flexure and peel tests to assure that the strength of each manufactured lot meets the required specifications.



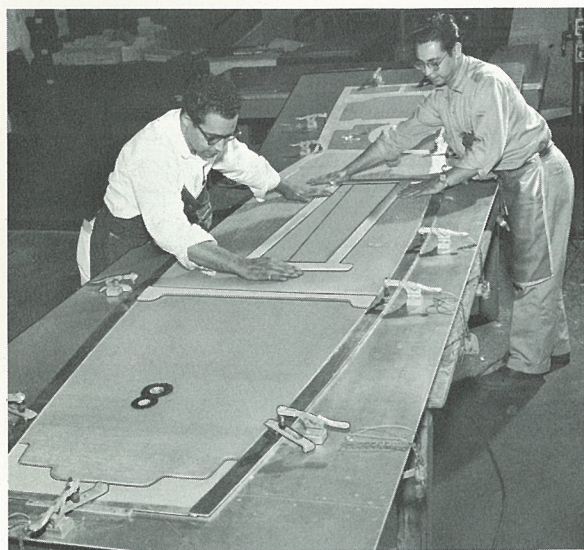
Honeycomb core of aileron trim tab assembly is being shaped with a high-speed cutter.



Honeycomb core before and after contour cutting. Cell edges are straightened to insure maximum bond.

Convair receives the honeycomb core in large flats, or logs, and cuts them to the required sizes and shapes. Shaping honeycomb core has been one of the obstacles that has hampered the product's growth, and the final breakthrough of this stumbling block has opened many new avenues for honeycomb applications.

For shaping large pieces of honeycomb core, Convair designed and built a high-speed horizontal bandsaw that cuts angles, flats, and curves. The bandsaw is cam-guided and universally-mounted to enable it to tip and swing fore and aft, making it an extremely versatile tool. The saw blade spans a five-foot throat, and is under 1000 or more pounds tension to prevent it from sagging. The work bed is seven feet long. The blade is driven by compressed air, the feed, by an electric motor. Interchangeable gearboxes on both sides of the feed permit one side to move slower or faster than the other. Cuts can be controlled to a tolerance of plus or minus 0.003 inch.

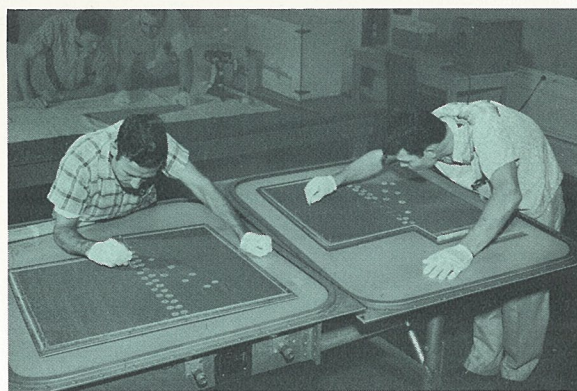


Floor of Convair 990 anti-shock body. Insert is fitted into honeycomb panel prior to metal bonding.

Small sizes of honeycomb core are fastened in jigs by special clamps, and are shaped by means of hand-held high-speed cutters and routers which follow the contours of profile and template guides attached to the jigs.

After the honeycomb core has been cut to the required size and shape, it is sent to the metal bond department where it is assembled together with facing sheets, edge members, inserts, and other parts required to make up a complete panel unit.

The metal bond department is located in a dust-free temperature-controlled room. Employees assembling panels are required to wear white gloves to prevent bonding surfaces from becoming contaminated. Honeycomb cores are carefully examined and all nicks and dents are straightened to assure uniformity of core surface. When all of the joining surfaces are meticulously clean and uniform, the panel is ready for a "lay-up" of bonding film. In most applications the



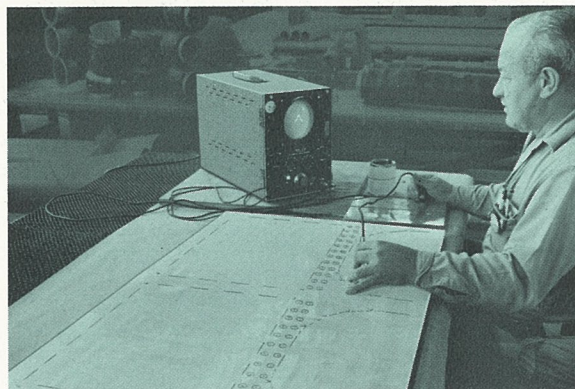
Lay-up of trailing edge wing panel assembly. Honeycomb core is being prepared for bonding to skin.

surfaces are first primed with liquid adhesive before the bonding film is applied.

The "lay-up" is made with AF (adhesive film) 202 for metal-to-core bonding, AF 204 for heat-resisting metal-to-core bonding, and AF 32 for metal-to-metal bonding. All excess film is trimmed off to keep the part as light as possible. Laminated cotton phenolic edge members are often fitted around the edges of the core. To prevent formation of voids inside the panel, metal is used in most cases where core inserts are specified. EC 1630 adhesive is used as a core-to-edge-member bond, and EC 1650 adhesive is used to bond inserts to core.

When the "lay-up" is complete, the entire panel is covered with a special rubber blanket which is sealed around the edges. The covered panel is then placed in an autoclave where it cures under a pressure of 50 psi at a temperature of 350° F.

The Coinda Scope (stub meter) ultrasonic inspection probes every square inch of completed honeycomb sandwich panel surface. Oakite CVAC 10150-33 (formula 59) is used as a probe lubricant and permits optimum contact and vibration sensations. The lubricant also prevents the panel skin from becoming scratched as the probe engages the surface.



Wing trailing edge door installation is being inspected ultrasonically by Coinda Scope (stub meter).

Emergency Airplane Lifting and Towing

Unusual circumstances, such as an inadvertent overrun of the landing strip, may so position the aircraft that unusual towing conditions may be necessary to return the aircraft to sound runways and normal handling conditions. If the aircraft has come to rest on uneven and/or soft terrain, and under conditions involving mud, water, and snow, the normal towing limitations and precautions, contained in the Maintenance Manual, should be carefully observed to avoid adding to any damage that may already have been incurred. The Maintenance Manual should also be studied if it is necessary to lift, shore, or turn the aircraft into the proper position for towing.

An adequate crew should be provided to man the aircraft and the towing vehicles, and to act as observers to prevent possible damage while the airplane is being towed. The aircraft brakes should be operative and manned so as to preclude the possibility of overrunning the towing lines and equipment, or to otherwise stop unwanted movement of the airplane at any moment.

The towing operation can be facilitated by removing loose and non-essential equipment and as much fuel as possible. In removing equipment to lighten the airplane, center-of-gravity location should be considered so that there is no possibility of the aircraft tipping. It should be borne in mind that the conditions of emergency towing will not be the same as those for normal towing, when uneven and potentially soft underfooting is encountered. Wind conditions should be considered because it is possible that the aircraft may inadvertently tilt to an unusual angle during the towing operation.

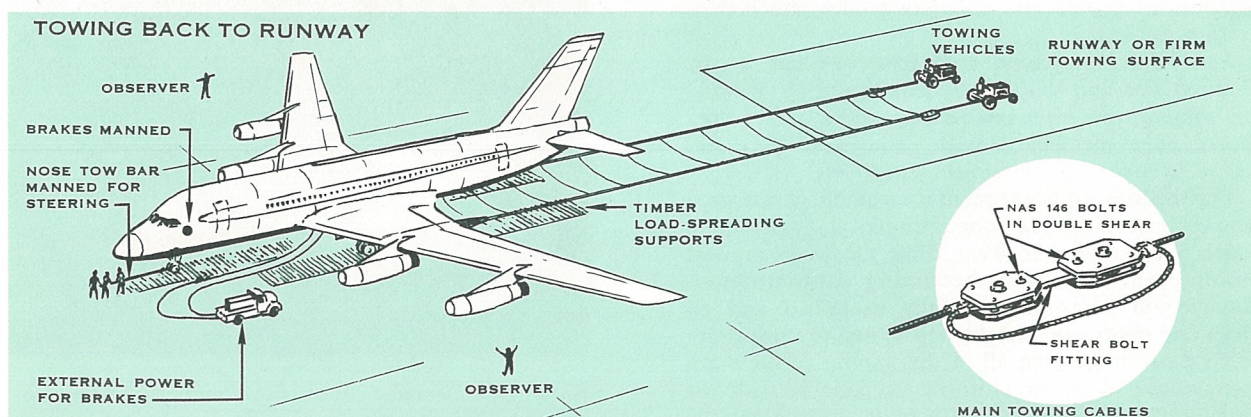
On a hard level runway, towing is accomplished at the nose landing gear. On rough terrain and/or soft ground, in mud, snow, etc, towing should be accomplished only from both main landing gears simultaneously. Front and rear towing lugs are provided on each main landing gear truck, providing for both forward and backward towing. When towing in a backward direction, the nose wheel tow bar should be attached to the nose wheel gear for steering only, and should be manned by several persons for adequate control. Sharp turns should be avoided.

A pair of towing cables of adequate strength and length should be attached to the main landing gear trucks, and extend parallel to the towing vehicles. Towing vehicles should be on a firm towing surface. Using towing cables of equal length will assure towing vehicle operators that the aircraft is being towed parallel to its axis and normal to the main landing gear trucks.

Bridging the two tow cables at frequent intervals, with lengths of manila rope, will restrain the whipping action of the tow cables if they should break or snap free under load, thus precluding damage to aircraft and equipment, or injury to personnel. Each end of both cables should be similarly provided with short lengths of lighter cable attached to the main towing cables, and with some slack at the attachment of the landing gear truck to the towing vehicle. These lighter cables will restrict the main tow cables, if the main attachment points should break free under load.

To preclude direct towing damage to the landing gear structure, each of the main tow-line cables should be rigged with NAS 146 shear bolt fittings. The NAS 146 bolt in double shear in the shear bolt fitting will shear before the main landing gear maximum permissible towing pull ($20,800 \times 1.26 = 26,200$ lb) can be transmitted to the main landing gear trucks. Some slack in the cable, which extends around the shear bolt fittings, will prevent excessive whip if the bolts are sheared in towing.

It is possible that the aircraft may have progressed to its resting position by traversing areas just firm enough to support it while traveling at relatively high speed. If the aircraft is towed back across this same area, the ground may not be sufficiently firm to provide adequate support for the aircraft weight, at the slow towing speed. If any indication of unfirm ground is noted, supporting timbers should be placed under and ahead of the wheels as the aircraft is towed. These should be of sufficient strength to distribute the wheel loading. Under wet or icy conditions, sand or similar material should be applied to the timbers to prevent the tires from slipping.



Beta Box Tester

A testing tool is used on the production line at Convair to regulate pressure and measure the flow of air passing through the Beta Box. By observing the flow of air to the box at a given pressure, the condition of the box can be determined. The tester may be used in service to check pressures and determine leakage rates if unsymmetrical rudder forces are encountered in flight. *Note: The Beta Box is discussed in detail in the November 1960 issue of the Traveler.*

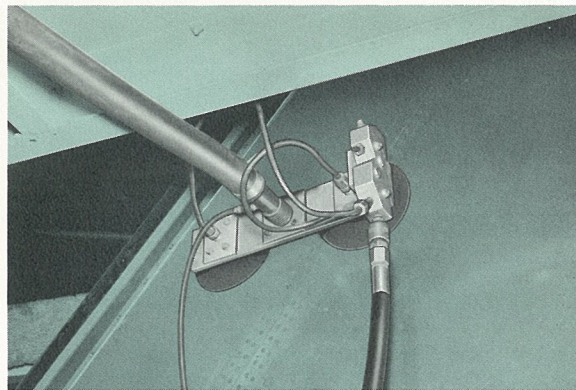
The Beta Box tool (TSTO 22-46246-1) is contained in a portable cabinet that is connected to a factory source of compressed air. Air lines extend from the portable cabinet to the Beta Box flush opening in the vertical stabilizer. Connection is made by pressing the test connection to the stabilizer skin by means of rubber suction cups. Suction on the cups is maintained by compressed air through a venturi-type, air-operated vacuum pump on the test connection.

The portable cabinet contains tubing and valves for introducing low air pressure to one side of the Beta Box. The pressure is shown on a manometer. When proper pressure is applied, the leakage (which is a function of the rudder deflection angle) can be checked.

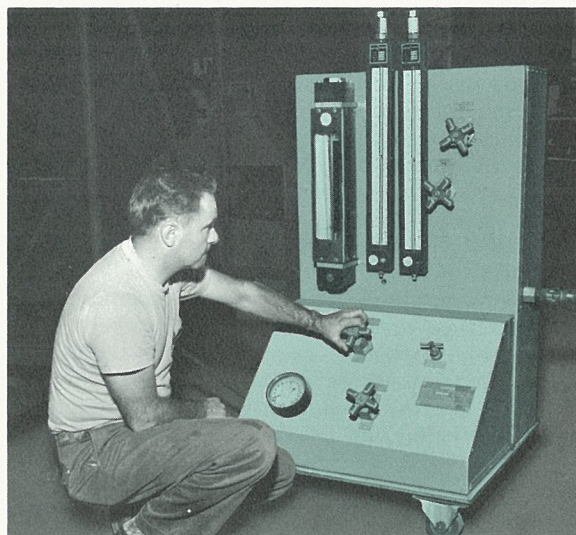
The testing pressures applied to the Beta Box are slightly above those encountered in flight (less than one pound per square inch). Because these low pressures are somewhat difficult to regulate with a mechanical pressure regulator, factory air is first passed through a filter, then through a regulator and into a surge tank, before being directed to the Beta Box.

In the event of tester malfunction, the Beta Box is protected against surges or excessive pressures by a relief valve that is included in the low-pressure line to the box.

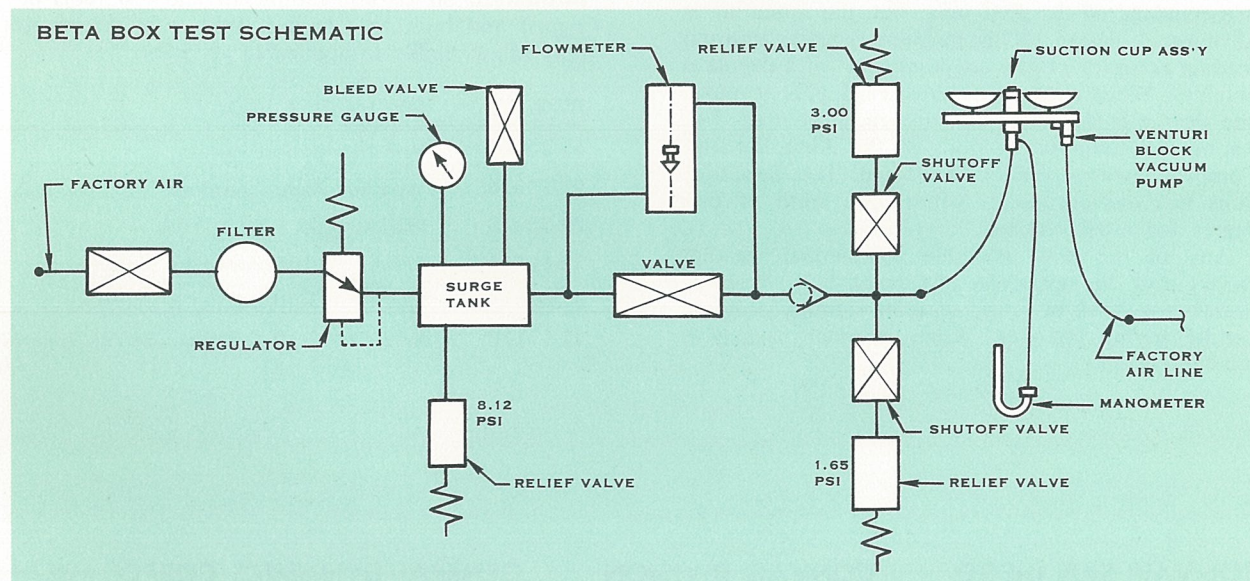
Drawings of the testing equipment may be obtained from Convair for local manufacture.



Connection to Beta Box is made by suction cups, which are maintained by source of compressed air.



Portable cabinet for testing Beta Box in rudder is connected to factory source of compressed air.



Electronic Equipment Testing and Installation

Convair 880/990

Before a Convair 880 or 990 jet airliner is delivered to a customer, it undergoes a thorough equipment and systems checkout. Every item, from a simple switch to the most complex electronic system, must be in perfect working order before an airplane is released.

The task of handling all black boxes and instruments that go to make up the complex communication and navigation systems of the Convair 880/990 aircraft is accomplished by Convair's Electronics Installation Department.

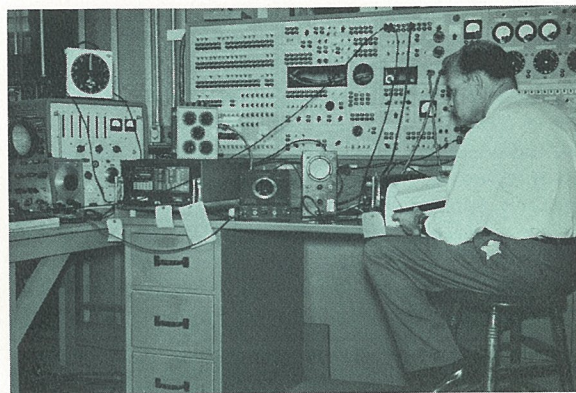
The number of systems handled will vary with individual airline requirements. They may include all or part of the Communications and Navigation Systems, DMET, ATC, Weather Radar, Terrain Warning, and Doppler.

Various test tools, which have no counterpart in commercially-available equipment, had to be built by Convair. As an example, two individual test tools were built to handle both Sperry and Bendix Autopilot and Compass systems...one for each vendor's equipment.

An interesting unit designed and built for use in conjunction with the Sperry Autopilot and Compass test tool is a small torquemeter for measuring minute rotational torque values, in either direction. The torquemeter indicates torque from 0 to 30 gram-centimeters with extreme accuracy.

Also used with the Autopilot and Compass test tools is a small precision synchro. The synchro itself is a standard off-the-shelf item, but, the mounting is of unusual design. With machined gears, unusual reading accuracy of one one-hundredth of a degree is obtained. When testing a compass card, plus or minus one degree is the maximum accuracy required. For testing the computer sections of the Autopilot and Compass systems, vendors' Customer Test Specifications call out accuracies within one tenth of one degree for a test synchro.

Any of the now available commercial weather radars may be tested on a Convair-built Weather Radar test stand by using separate dummy plugs to handle wiring changes. When a radar system is



Engineer checks out Bendix autopilot and Polar Path compass system on Electronics Test Bench.

checked out on the test stand, all components are readily accessible for adjustment and calibration as required. The location of the testing area is such that mountains, extending from 19 to 37 miles at a known azimuth bearing, are used for calibration purposes. Either a vertical gyro or an accurate simulated gyro signal may be used for adjustment of the stabilization circuits along with physical displacement of the radar antenna in roll and/or pitch.

Complete operating instructions and blueprints are maintained on all test equipment and test tools designed and built by Convair. With few exceptions, they are available to applicable agencies.

TSTO NO.	SPECIAL TEST TOOL
22-30308	VHF Navigation Systems
22-30323	Weather Radar Systems
22-30325	SELCAL Units
22-60501-3	Bendix PB-20G Autopilot & Compass
22-60501-4	Sperry SP-30 Autopilot & Compass
22-91170	Modified C-10 Compass Swing System

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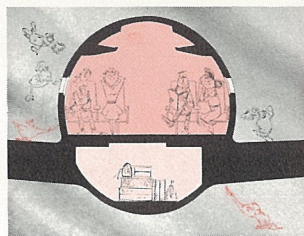
Convair *Traveler*



*In this Issue: Cabin Temperature Control — Convair 880/990
Principal Airplane Clearances — Convair 880
Electrical Protectors — Convair 880/990*

VOLUME XII NUMBER 11 MARCH 1961

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OUR COVER

Hot and cold gremlins have little effect on Convair 880/990 interiors which, regardless of outside conditions, maintain a comfortable temperature for passengers and crew. The artist — Willis Goldsmith.

Convair Traveler

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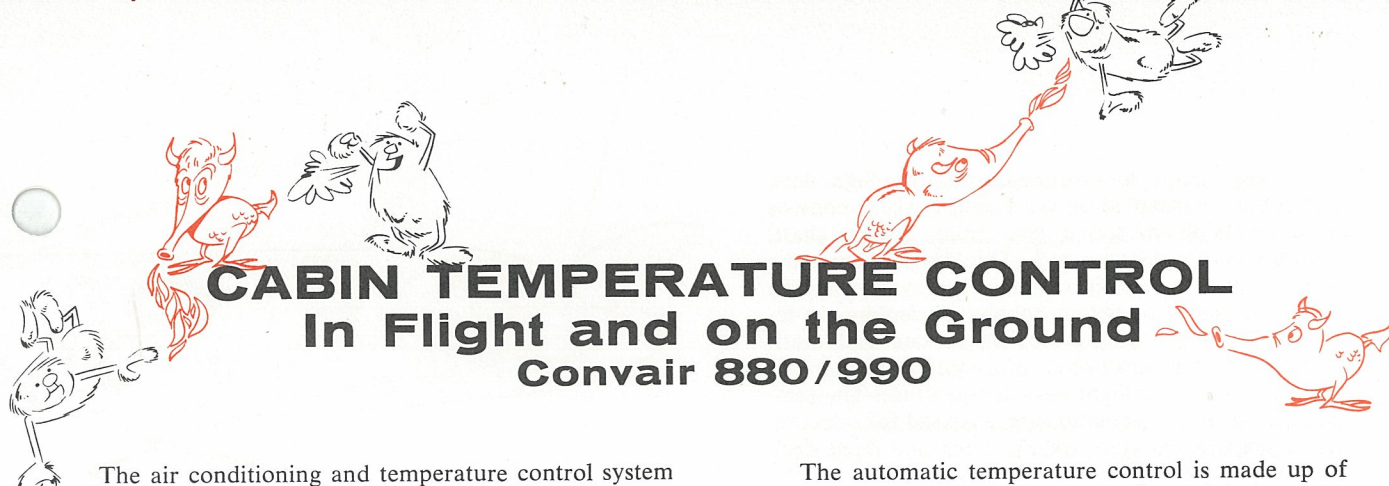
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N. V. Davidson

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CONVAIR-SAN DIEGO/CONVAIR DIVISION OF GENERAL DYNAMICS CORPORATION



CABIN TEMPERATURE CONTROL

In Flight and on the Ground

Convair 880/990

The air conditioning and temperature control system on the Convair 880/990 jet airliners is designed to offer maximum comfort to passengers and flight crew during flight and while the airplane is on the ground. The system also protects susceptible aircraft equipment from temperature extremes that might interfere with their operation.

Through the coordinated operation of the various components that make up the air conditioning system, the following six basic functions are achieved: cabin pressure, air heating, air cooling, removal of excess moisture from cabin air, control of cabin air temperature, and ventilation.

At an altitude of 35,000 feet, the flight and passenger compartments are supplied with an airflow of approximately 110 pounds per minute. The passenger compartment receives a complete change of air every two and one-half minutes; the flight compartment, every minute. The cabin pressurization system is capable of maintaining the cabin altitude at sea level up to an airplane altitude of 21,300 feet, and the cabin altitude at 8,000 feet up to an airplane altitude of 41,000 feet.

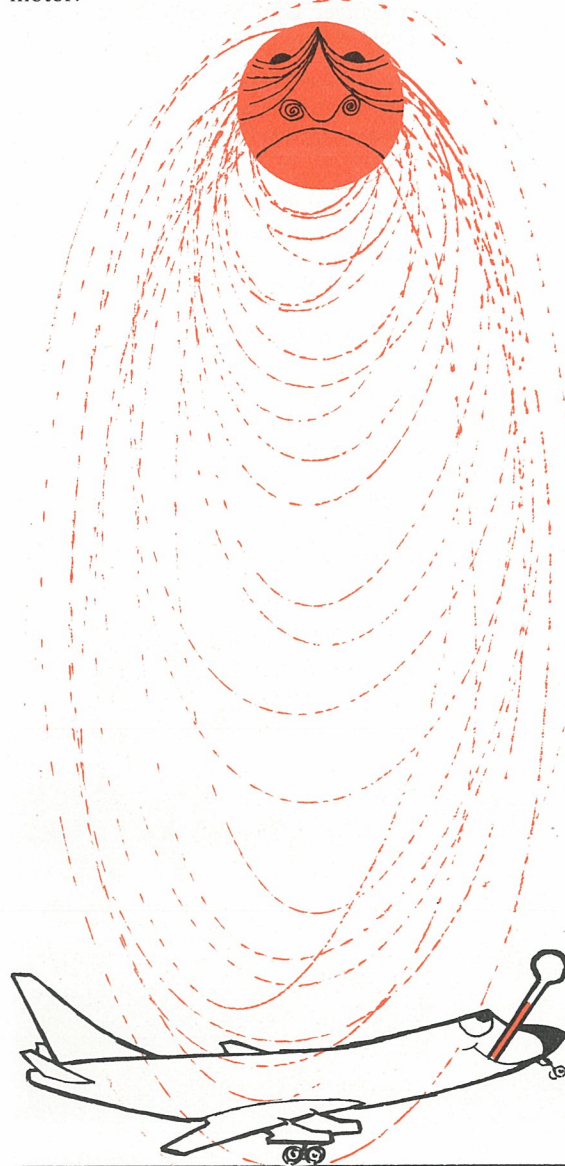
Despite the wide range of outside temperatures encountered during the course of high-altitude flight, the air conditioning and temperature control system will maintain cabin temperature at a comfortable 75°F (23.9°C). During ground operation, temperature on a 100°F (37.8°C) day will not exceed 80°F (26.7°C). The baggage compartment temperature is maintained above freezing at flight ambients down to -80°F (-62.2°C).

The flight deck and cabin temperature control systems on the Convair 880/990 are, for the most part, identical. Although interconnected by the necessary valving, they are normally independent of each other. To simplify the text, reference will be made only to the passenger cabin and, because customer requirements and installations of different models vary somewhat, a typical system will be discussed.

Normal in-flight and ground operation control of the air conditioning unit is accomplished automatically by the temperature control system. When in AUTO mode, the system keeps the cabin temperature at the setting of the temperature selector, and limits the inlet duct temperature to a maximum of 130°F (54.4°C).

Manual operation of the system is possible through the use of two toggle switches on the control panel. These switches function only when the AUTO-MAN-OFF switch is in the MAN position. The amount of heating or cooling is dependent on how long the MAN HOT-MAN COLD switch is held in the hot or cold position.

The automatic temperature control is made up of a comparison network, a magnetic modulator, three amplifiers, and the power supply. The comparison network incorporates a bridge circuit for compartment temperature error, and another for duct temperature limit. The magnetic modulator utilizes ac voltage to convert a dc temperature error signal into an ac voltage which is amplified to drive the sequencing device motor.



The sequencing device (one each for the flight deck and cabin) is installed on the Freon Pack. It consists of a reversible motor, a gear train, a cam shaft, switches, and potentiometers. This device signals the components of the air conditioning system in the proper sequence to obtain heating or cooling, as required. The sequencing device is positioned automatically by the temperature control system to maintain a selected cabin or flight deck temperature. The temperature selector (potentiometer) is used for selecting the desired temperature for the cabin and flight deck in AUTO. Placing the temperature selector in the desired position to either increase or decrease the conditioned air temperature causes a comparison of signals between the thermal resistors and temperature selector. The error signal causes the temperature control to position the sequencing device and thus schedule the following components and systems.

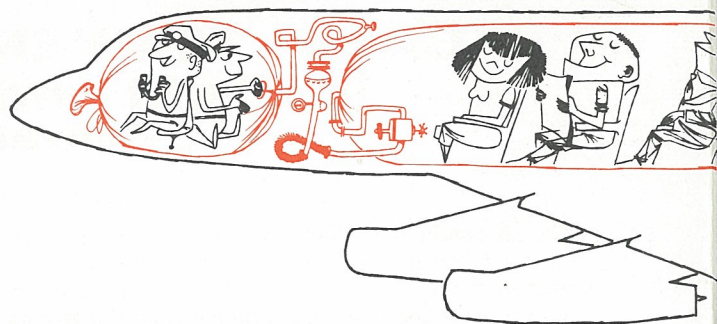
In-Flight Operation: Cabin heat control modulating valve; heat exchanger cool air modulating valve; Freon vapor cycle system control.

Ground Operation: Cabin air recirculation control valve and cabin fresh air control valve (on some airplanes); turbocompressors; Freon vapor cycle system control.

Electric heaters, cabin fresh air valve and cabin recirculation control valve, and components of the differential control system are scheduled by the sequencing device on those 880/990 aircraft so equipped.

Cabin and flight deck temperatures are sensed by thermal resistors located in the air exit ducts. They are electronically compared with the selected compartment temperature, and the difference between the selected and actual compartment temperatures actuates the sequencing device.

The Freon cooling system consists of closed vapor cycle refrigeration units containing fluid that absorbs heat during vaporization, and releases heat during condensation.



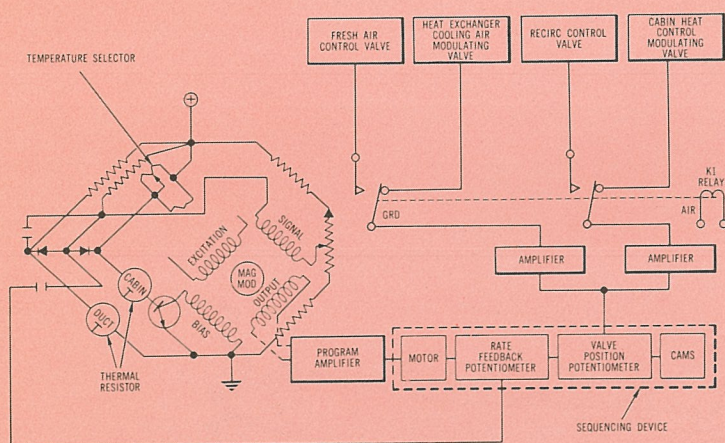
A group of switches and indicators are available to control and monitor the Freon refrigeration subsystem. These controls consist of a Freon ON-OFF switch, a cabin/flight deck control switch, recirculation fan switch, ram air source switch, malfunction lights for both Freon systems, and a cabin temperature indicator. A separate ON-OFF switch is available for the electronic compartment cooling fan and valve.

While the airplane is in flight, the turbocompressor system normally furnishes pressurized air to the cabin. Heating is gained by action of the cabin heat control modulating valve, which allows pressurized air to recirculate through the turbocompressor, and is regulated by the amount the valve is opened. Primary cooling is provided by the heat exchanger and is regulated by the heat exchanger cool air modulating valve. Secondary cooling is furnished by the Freon vapor cycle system.

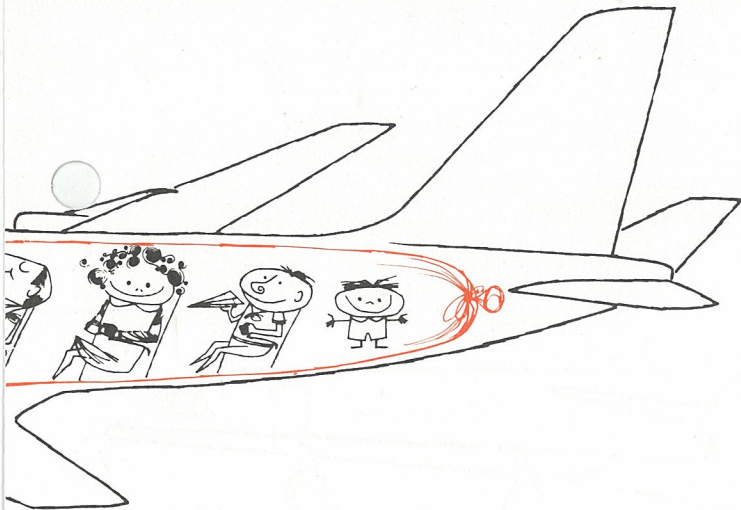
For maximum cabin cooling, in the electric-driven system, the cabin heat control modulating valve is closed, and the heat exchanger cool air modulating valve and the Freon back pressure regulating valve are fully opened. The turbocompressor system provides pressurized air which is ducted to the heat exchanger where it is cooled by ram air cooling from the open heat exchanger cool air modulating valve. From the heat exchanger, the pressurized air is ducted to the Freon evaporator and, because of the fully opened back pressure regulating valve, receives maximum Freon vapor cycle cooling. The cooled and dehumidified air then flows into the cabin, resulting in maximum cabin cooling.

To reduce cooling of the cabin air to the setting of the temperature selector, the back pressure regulating valve is slowly closed by the sequencing device. The cooling capacity of the Freon system is thus reduced and the Freon compressor shuts down when the back pressure valve closes. To further reduce cooling, the heat exchanger modulating valve is slowly closed by the action of the temperature control amplifiers.

Some models of the Convair jet airliner have movable cabin partitions that can be relocated to divide the forward and aft sections of the cabin into different sizes to accommodate different seating arrangements. Because of the difference in passenger loading that is possible in the two compartments, a differential temperature control system is necessary to maintain the cabin air discharge temperature within 2°F.



Typical temperature control schematic



The differential temperature control system consists of a temperature differential control box, a modulating power supply, a ground modulating power supply, two discharge air temperature sensors, two inlet air temperature sensors, and two dual electric cabin air heaters.

The amount of temperature differences between the two compartments is determined by the discharge sensors which send signals to the control box. The control box compares the signals and determines the coldest compartment and the amount of temperature difference. The modulating power supply, monitored by the control unit, automatically applies power to the two heaters in the coldest compartment at a rate determined by the temperature differential at the discharge sensors. This rate of heat application is compatible with the rate of temperature change that is determined by the inlet sensors which also supply signals to the control unit.

On the ground, the turbocompressor system is used for temperature control on those 880/990 aircraft not equipped with the cabin/electric heaters. On models equipped with the cabin heaters, the turbocompressor system is normally not used during ground operations.

On heater-equipped models, the cabin air recirculating fan supplies air to the cabin. Ground cooling the cabin air is accomplished by the Freon vapor cycle system; ground heating the cabin air is performed by the cabin electric heaters. Various cooling and heating conditions are made possible by regulating the cooling capacity of the Freon vapor cycle system via the back pressure regulating valve, or regulating the cabin electric heaters.

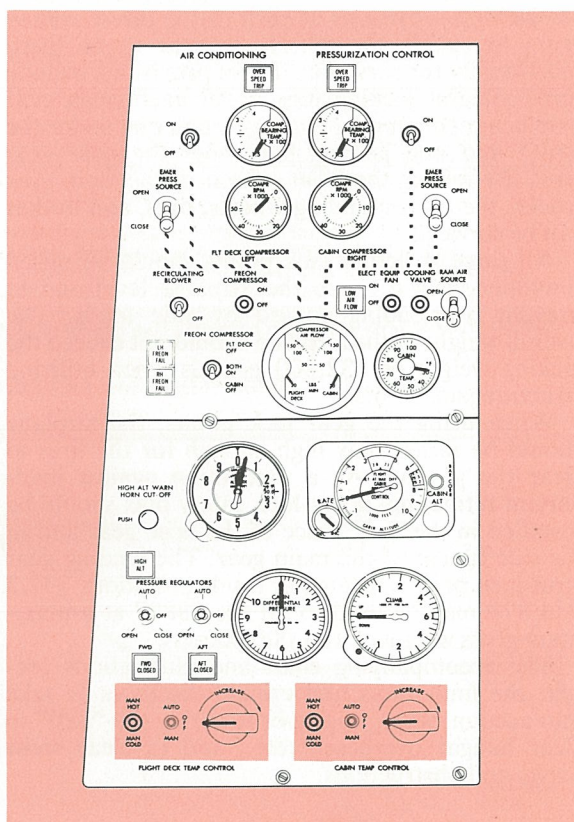
When maximum cabin cooling is scheduled on the ground, the cabin electric heaters are off, the fresh air control valve (on some models) is closed, the back pressure regulating valve and the recirculation control valve are fully opened. Cabin air is drawn through the open air valve by the recirculation fan and is ducted to the Freon evaporator for maximum cooling. Leaving the evaporator, the cooled air is ducted into the cabin through the inoperative electric duct heaters.

On those aircraft with the fresh air valve, the sequencing device gradually closes the recirculation control valve and slowly opens the fresh air control valve, in the event the cabin air requires less cooling, thereby increasing the temperature of the air entering

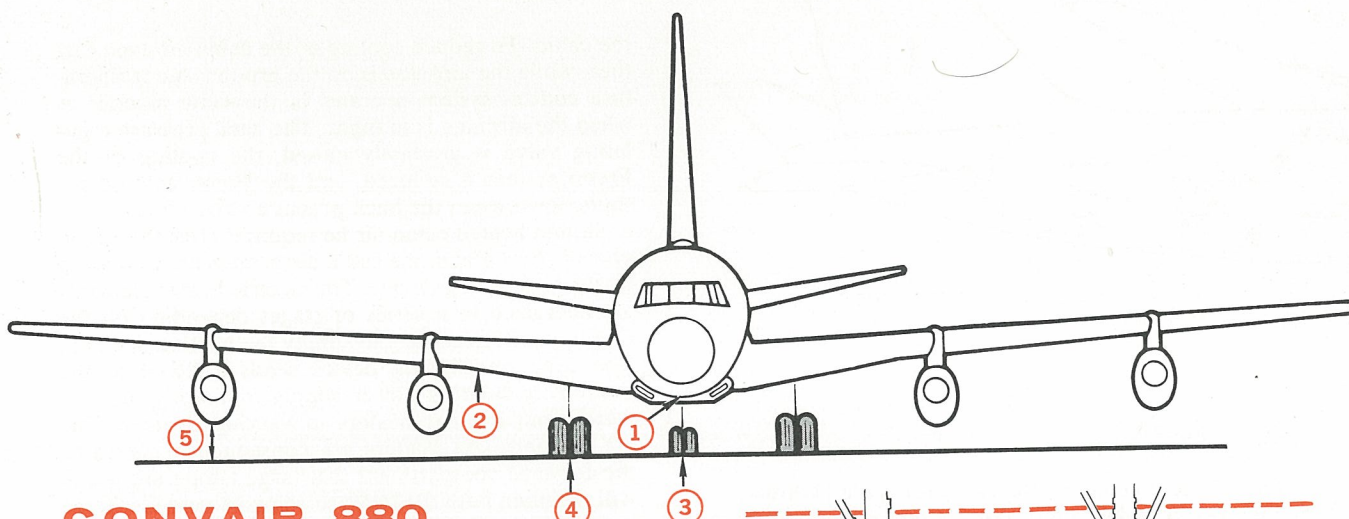
the cabin. To reduce cooling of the cabin air even further, while the airplane is on the ground, the temperature control system operates in the same manner as when the airplane is in flight. The back pressure regulating valve is gradually closed, the cooling of the Freon system is reduced, and the Freon compressor shuts down when the back pressure valve closes.

Should heated cabin air be required after the Freon system shuts down, the cabin air heaters are turned on by the sequencing device. The electric heater elements are energized in a series of stages depending on the requirements necessary to supply the heating demand. The cabin sequencing device sends a signal to the ground modulating power supply, operating the forward compartment heaters in varying degrees. The aft compartment heaters are consequently slaved to the forward compartment discharge temperature and will maintain both the forward compartment discharge temperature and the aft compartment discharge temperature within 2°F of each other.

If additional cabin air heating is required after the cabin air electric heaters are fully energized, the sequencing device will slowly close the fresh air control valve (if installed) as it opens the cabin air recirculation control valve. With the fresh air control valve fully closed, the cabin air recirculation control valve opened, and all electric heater elements energized, the temperature control system will provide maximum cabin air heating.



Typical controls for regulating temperature of cabin and flight deck on Convair 880/990.



CONVAIR 880 PRINCIPAL AIRPLANE CLEARANCES

To raise the Convair 880 entirely off the ground, three airplane structure jack points are used: the fuselage (nose) jack point at bulkhead station 153.6, just aft of the radome; and one jack point on each wing at wing station 224.7, four inches aft of the rear spar at fuselage station 887.4.

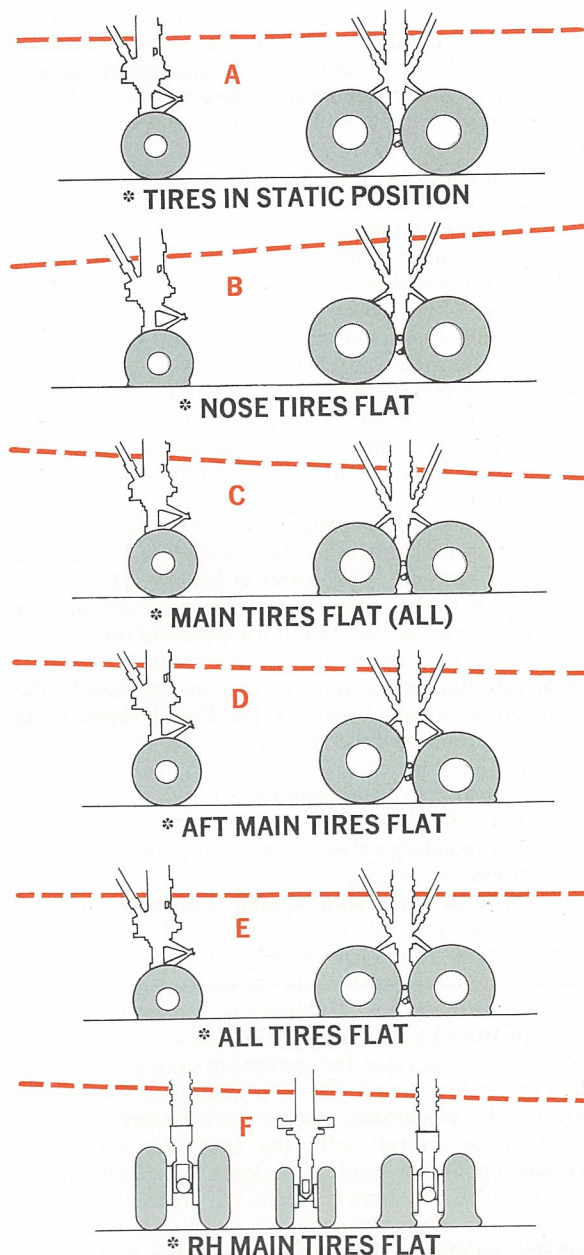
In addition to the structure jack points, there are jacking provisions at each of the three landing gears to enable the wheels or gear to be lifted individually for servicing. These provisions include three integral jacking lugs under each main gear axle beam (one under each axle and one under the strut) and one jacking lug under the nose gear strut. By raising the front or rear of the main gear trucks, the corresponding wheels, tires, and brakes can be serviced.

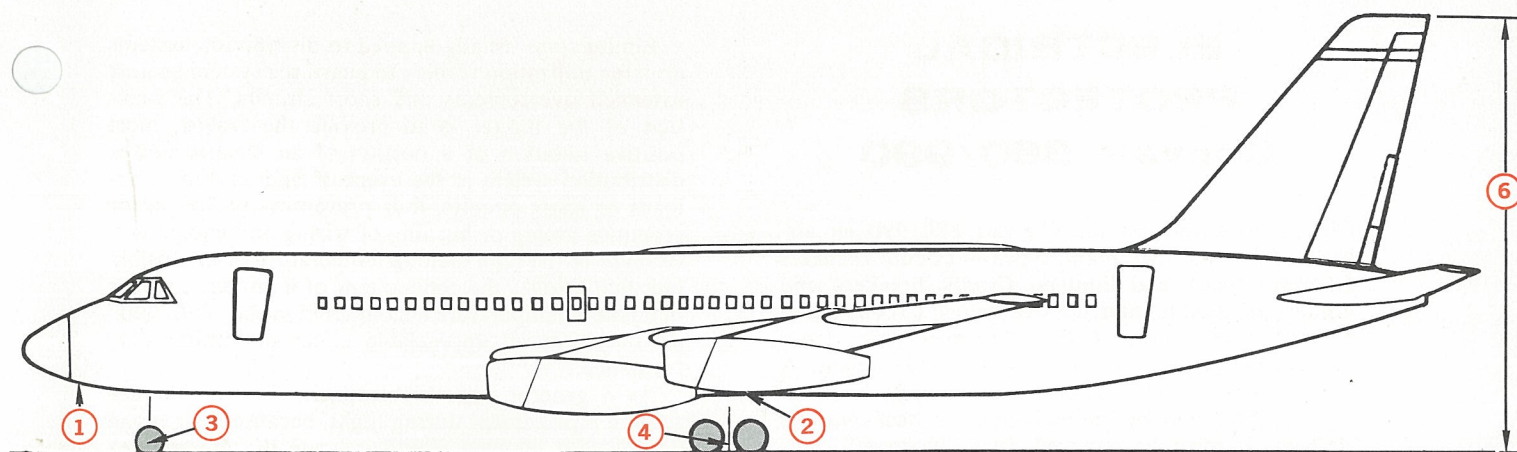
All three structure jack points should be raised simultaneously to keep the airplane level and to prevent overloading caused by side loads. The overall weight of the airplane should not exceed the jacking weight of 132,800 pounds when utilizing structure jack points.

When using the gear jack points, the airplane should be raised only high enough for the tires to clear the ground. As a precaution against inadvertent retracting, down-lock safety pins should be installed in the drag brace of the nose gear and in the side braces of the main gear. The landing gear strut jack points, located at fuselage stations 231.3 and 878 may be used to lift the "880" at a maximum gross weight of 185,000 pounds.

The accompanying chart and illustrations present the limitations and critical distances to take into account when raising or lowering the "880" to clear hangar overhangs, etc., and to clear snow banks and obstructions.

* ALL STRUTS NORMAL
‡ ALL TIRES INFLATED





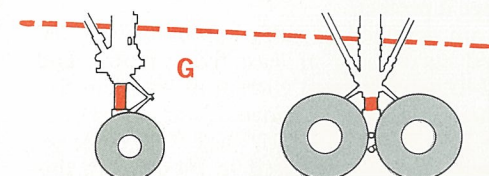
- ① NOSE JACK POINT ④ MAIN GEAR JACK POINT
- ② WING JACK POINT ⑤ OUTB'D POD CLEARANCE
- ③ NOSE GEAR JACK POINT ⑥ EMPENNAGE CLEARANCE

CLEARANCES IN INCHES

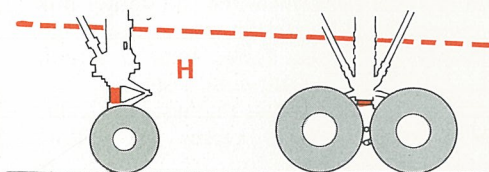
	①		②		③		④		⑤		⑥
	LH		RH		STRUT		AXLE		LH		RH
A	70.40	99.55	99.55	13.90	11.63	FORE 12.53 AFT 11.90	43.50	43.50	442.80		
B	68.47	99.55	99.55	12.20	11.63	FORE 12.53 AFT 11.90	43.50	43.50	444.71		
C	71.02	91.25	91.25	13.90	7.10	FORE 8.00 AFT 7.38	38.97	38.97	437.69		
D	70.73	93.37	93.37	13.90	9.22	FORE 12.56 AFT 7.80	41.09	41.09	440.10		
E	69.09	91.25	91.25	12.20	7.10	FORE 8.00 AFT 7.38	38.97	38.97	435.08		
F	70.71	101.78	92.79	13.90	7.10	FORE 8.00 AFT 7.38	51.15	31.32	440.25		
G	77.70	99.46	99.46	13.90	11.63	FORE 12.53 AFT 11.90	43.50	43.50	435.60		
H	72.10	87.00	87.00	13.90	11.63	FORE 12.53 AFT 11.90	31.20	31.20	416.60		
I	69.90	103.30	103.30	13.90	11.63	FORE 12.53 AFT 11.90	47.20	47.20	450.70		
J	71.30	105.60	81.20	13.90	11.63	FORE 12.59 AFT 11.90	64.20	10.50	429.70		
K	70.10	97.70	105.10	13.90	11.63	FORE 12.53 AFT 11.90	37.30	53.40	446.60		

Difference between inflated and deflated nose gear tire is 1.70 inches.
 Difference between inflated and deflated main gear tire is 4.53 inches.
 Difference between compressed and bottomed nose gear strut is 6.60 inches.
 Difference between compressed and bottomed main gear strut is 12.30 inches.
 Difference between fully extended and bottomed nose gear strut is 13.00 inches.
 Difference between fully extended and bottomed main gear strut is 16.00 inches.

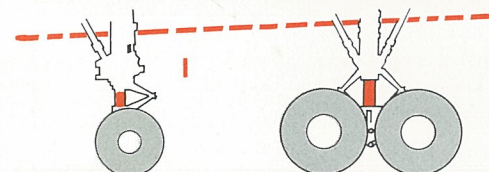
CLEARANCES FIGURED AT JACKING WEIGHT OF 132,800 lb.



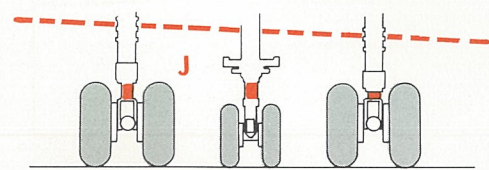
‡ NOSE STRUT INFLATED (EXTREME)



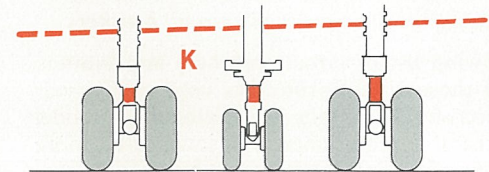
‡ MAIN STRUTS BOTTOMED



‡ MAIN STRUTS INFLATED (EXTREME)

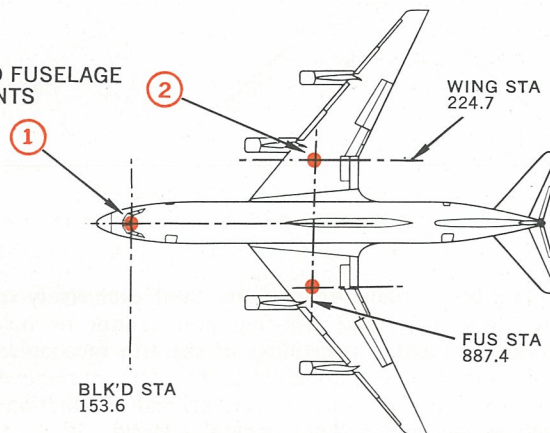


‡ RH MAIN STRUT BOTTOMED



‡ RH MAIN STRUT EXTENDED

WING AND FUSELAGE
JACK POINTS



ELECTRICAL PROTECTORS

Convair 880/990

Circuit protectors on the Convair 880/990 jet airliners fall into two main types — circuit breakers (thermal type) and limiters. Circuit breakers and limiters are used to interrupt overloaded circuits under prescribed conditions. Circuit breakers differ from limiters in that they do not require replacement. A limiter causes an electric circuit to open under over-current conditions by the melting of its heat-sensitive element. It must be replaced after "blowing."

The receptacles for electrical protectors are clearly marked with appropriate amperage ratings. Each electrical protector is marked with its amperage rating and either a military specification (MS) number or the vendor's part number.

Circuit breakers and limiters are selected to give maximum protection by preventing electrical wiring from exceeding maximum operating temperatures. When necessary, the difference in ambient temperature between the circuit breaker and the wire location is taken into account.

The maximum current that a circuit breaker can safely interrupt is about 3500 amperes at 120 volts. They are designed to have an ultimate trip time at a temperature of 77°F, and will trip at 115 to 138 percent of rated current up to an altitude of 50,000 feet. Circuit breakers have the same ac and dc characteristics since their operation is caused by the heating effect of the load current.

Circuit breakers are usually located so they will be accessible for resetting during flight. They are also located as close as possible to their applicable bus to keep the amount of unprotected wiring to a minimum.

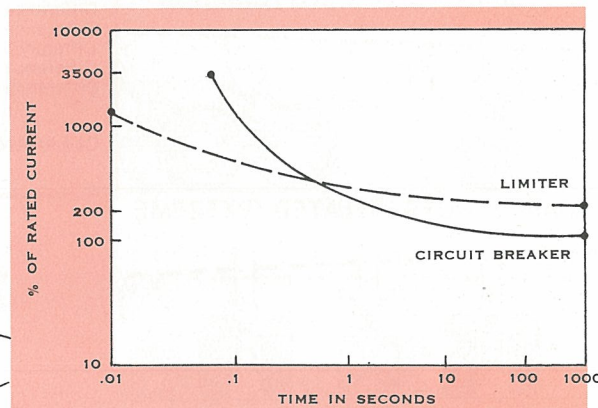
Limiters are usually applied to distribution systems on large utilization feeders to guard the system against extended overcurrents and short circuits. The function of the limiter is to provide the fastest, most positive isolation of a portion of an electric power distribution system in the event of high current overloads or short circuits, thus preventing prolonged or repetitive arcing or burning of wiring and equipment. Because of the high melting temperature of the fusible link that bridges the connections of a limiter, changes in ambient temperature encountered in the "880/990" do not have an appreciable effect on limiter performance.

As a general rule, high-capacity limiters do not require replacement during flight, because their usage is such that blowing would indicate the presence of faults that could not be repaired by the flight crew. Re-energizing the circuits could result in structural damage and/or fire.

The same general type of limiter is used throughout the Convair 880/990 airliner for both ac and dc power. Since limiters, like thermal circuit breakers, are heat-sensitive devices, they function irrespective of ac or dc. The rating of a limiter is determined by the wire gauge it protects.

Limiters are designed to carry approximately 200 percent rated current for at least five minutes, and to blow at 240 percent rated current in less than five minutes. Their interrupting capacities at 400 cycles are 4000 to 2500 amperes at 120 and 208 volts, respectively, and they are required to function in this capacity at altitudes up to 50,000 feet. A small button at one end of the unit pops out when the limiter link has melted, giving visual indication that a limiter has blown. A limiter will open faster than a circuit breaker under high current fault conditions.

The accompanying curve shows the basic trip characteristics of a circuit breaker versus the melting curve of a comparable limiter.



Shown above is graph comparing typical performance curves of limiters and circuit breakers.

The following list of circuit breakers and limiters is typical of those circuit protectors used on Convair 880/990 aircraft. Variations are dictated by model types and customer requirements. In some cases, more than one item of equipment is served by a single protector, when contained in the same circuit.

Trip-free circuit breakers are used exclusively on the "880/990." The trip-free unit cannot be held closed by manual overriding of the trip mechanism while a tripping condition exists. This feature removes the possibility of burning out critical installations, such as emergency flight control systems.

EQUIPMENT	PROTECTOR	SIZE	QTY	LOCATION
POWER				
Battery T-R Unit	Limiter	5A	3	DC Pwr Emerg Bus
Ess Override AC	CB	10A	2	Main CB Panel
Ess Override DC	CB	50A	1	
Ess Override DC	CB	20A	1	
Ess Override DC	CB	10A	1	
Gen AC Pwr Cont	CB	3A	4	
Battery Relay Cont	CB	2A	1	
Utility Receptacle	CB	7.5A	1	
28V Emerg Transf	Limiter	10A	1	Dist, DC Pwr, Emerg Bus
T-R 4	Limiter	5A	3	
AC Pwr Cont	Limiter	15A	1	
Battery	Limiter	30A	3	
Grd Maint Pwr	Limiter	25A	2	Ext Pwr Junc Box
Main Seq Relay & T-R	Limiter	5A	3	
T-R Unit Out	Limiter	5A	1	
Aux Phase Seq Relay	Limiter	5A	3	
Pilot Ess Bus Mtr Relay	Limiter	15A	3	
Sync Bus Protect Relay	Limiter	5A	3	
Baggage Loader Pwr	Limiter	15A	3	
DC Preload Baggage	Limiter	5A	1	
Dist Bus Pwr	Limiter	40A	27	AC Pwr Junc Box
Gen Cont Pwr	Limiter	5A	12	
Pilot Ess Bus Pwr	Limiter	15A	12	
Voltmeters KW & KV	CB	2A	12	
T-R 1, 2, 3, 4	Limiter	50A	4	Electric Rack
Emerg Bus Feeder	Limiter	30A	3	Battery Junc Box
Battery T-R	Limiter	20A	1	
VM Sel Sw	Limiter	5A	1	
DC Pwr Cont	Limiter	10A	1	
Cargo Hoist Pwr	Limiter	10A	3	Cargo Ldr Junc Box
Cargo Ldr Pwr	Limiter	10A	3	
Tow Pwr Cont	Limiter	5A	3	Ext Pwr Nose Towing
Tow Pwr	Limiter	40A	3	
T-R Unit No. 3	Limiter	5A	3	AC Pwr Dist Box
AC Pwr	Limiter	5A	1	
Elec Compt Blower	Limiter	5A	3	
AC Pwr	Limiter	5A	3	
Ess Ltg Transf 28V	Limiter	30A	1	
T-R Unit No. 1	Limiter	5A	3	
T-R Unit No. 2	Limiter	5A	3	

POWER PLANT				
Guide Vane, Nose Cone, Anti-Ice Valve, Eng Inlet	CB	3A	4	Main CB Panel
Start Valve	CB	2A	4	
CSD Cont	CB	10A	4	
Ign Pwr	CB	3A	4	
Ign Cont	CB	3A	4	
Anti-Vortex, Grd Cool	CB	5A	4	
Eng Start Rev Thr	Limiter	15A	1	Dist, DC Pwr, Emerg Bus
Emerg, Ign Static Inv	Limiter	3A	1	

FUEL SYSTEM				
Defuel Valve	CB	5A	2	Main CB Panel
Refuel Valve S/O Solenoid	CB	5A	2	
Refuel Cont	CB	5A	1	
Fuel Temp Ind	CB	2A	1	
Fuel Line Valves	CB	3A	4	
Fuel Emerg S/O Valves	CB	3A	4	
Fuel C/F Valves	CB	3A	4	
Fuel Pump Warn.	CB	2A	4	
Jettison Valves	CB	2A	4	
Scavenge Valves	CB	2A	2	
Fuel Emerg Crossfeed	CB	2A	1	
Fuel Flow Ind	CB	2A	4	
Fuel Boost Pump Cont	CB	5A	8	
Fuel Trans Pump Cont	CB	5A	8	
Fuel Qty Ind	CB	5A	4	
Fuel Pump Warn. Lts, Tank	CB	2A	4	
Fuel Control	Limiter	20A	1	Distr, DC Pwr, Emerg Bus
Fuel Pumps, Temp Ind	Limiter	10A	1	
Fuel CSD Cont	Limiter	20A	1	
Fuel Trans Pump	Limiter	3A	24	AC Pwr Dist Box
Fuel Boost Pumps	Limiter	3A	24	
Fuel Qty, Oil Qty	Limiter	20A	1	

EQUIPMENT	PROTECTOR	SIZE	QTY	LOCATION
OIL SYSTEM				
Oil Qty Ind	CB	5A	4	Main CB Panel
Oil Press. Ind	CB	2A	4	
Eng Oil Temp Ind	CB	2A	4	
Oil Qty, Fuel Qty	Limiter	20A	1	AC Pwr Dist Box

HYDRAULIC SYSTEM				
Hyd Pump S/O Valve	CB	2A	1	Main CB Panel
Hyd Press. 1 & 2	CB	2A	2	
Hyd Temp Cont 1 & 2	CB	2A	2	
Hyd Pump Motor Cont	CB	3A	1	
Hyd Fluid Qty Ind	CB	2A	1	
Hyd Brake Press. Ind	CB	2A	1	
Hyd Cont Eng A-I	Limiter	15A	1	Dist, DC Pwr, Emerg Bus
Hyd Fluid Qty, Air Cond, Pass. Wtr, Ice Det, Eng	Limiter	20A	1	AC Pwr Dist Box
Hyd Pump Motor Cont	Limiter	10A	1	
Hyd Pump Motor	Limiter	25A	3	

CABIN PRESSURE & AIR CONDITIONING				
Elec Cool Valve	CB	3A	1	Main CB Panel
Freon Cont — Cabin	CB	5A	1	
Freon Cont — Flt Deck	CB	5A	1	
Cab/Flt Deck Air S/O	CB	2A	1	
Ram Air S/O Valve	CB	2A	1	
Evap Air Manf S/O Valve	CB	2A	1	
Elec Temp Cont — Cabin	CB	2A	1	
Elec Temp Cont — Flt Deck	CB	2A	1	
Cond Grd Cool — Cabin	CB	2A	1	
Cond Grd Cool — Flt Deck	CB	2A	1	
High Duct Press. Warn. Lt	CB	5A	1	
Air Flow Ind	CB	5A	1	
Recirc Fan Cont	CB	5A	1	
Freon Cont	CB	5A	1	
Cabin Press. Reg	CB	2A	2	
Turbo Compr Off — Cabin	CB	2A	1	
Turbo Compr Off — Flt Deck	CB	2A	1	
Turbo Compr On, Cabin	CB	5A	1	
Turbo Compr On — Flt Deck	CB	5A	1	
Turbo Compr Ind — Cabin	CB	5A	1	
Turbo Compr Ind — Flt Deck	CB	5A	1	
Emerg Press. — Cabin	CB	2A	1	
Emerg Press. — Flt Deck	CB	2A	1	
Elec Compt Fan Cont	CB	2A	1	
Cabin Air Temp	CB	2A	1	
Free Air Temp Ind	CB	2A	1	
Press. Reg Pos Lts	Limiter	15A	1	Dist, DC Pwr, Emerg Bus
Air Cond.	Limiter	20A	1	
Flt Deck Heater	CB	15A	12	Relay, CB, Temp Cont
Cabin Heater	CB	15A	12	
Air Cond	Limiter	5A	1	AC Pwr Dist Box
Air Cond, Pass. Wtr, Eng Ice Det, Hyd Fluid Qty	Limiter	20A	1	

RAIN, FOG, ICE PROTECTION				
Pitot Tube Heater	CB	5A	2	Main CB Panel
Wing A-I Cont	CB	5A	2	
Tail A-I Cont	CB	5A	1	
Rain Clear, Ovht Cont	CB	3A	1	
Tail A-I Cont, Ind	CB	5A	1	
A-I Lts, Ind — LH				
Wing Valve Relay	CB	5A	1	
Wdshld Rain Clear Valve	CB	5A	1	
Wdshld A-I, Defog	CB	2A	3	
Sliding Windows Defog	CB	5A	1	
Pilot Aft Windows Defog	CB	5A	1	
Ice Det — Eng 1 & 3	CB	3A	2	
Wing Vent Scoop, D-I Boot	CB	5A	2	
Pass. Call, Rain Clear, Radome	Limiter	20A	1	Dist, DC Pwr Emerg Bus
Anti-Ice Wing & Tail	Limiter	20A	1	

EQUIPMENT	PROTECTOR	SIZE	QTY	LOCATION
RAIN, FOG, ICE PROTECTION — CON'T.				
Eng Ice Det, Air Cond, Pass. Wtr, Hyd				AC Pwr Dist Box
Fluid Qty	Limiter	20A	1	
Wdshld A-I, RH	Limiter	10A	2	
Wdshld A-I, LH	Limiter	10A	2	
Temp Ind, A-I	Limiter	15A	1	
Tail Anti-Ice	Limiter	30A	3	
Ctr Wdshld A-I	Limiter	10A	2	
Recirc Fan	Limiter	60A	3	
RH Window Defog, Lav & Closet Lts	Limiter	20A	1	
LH Window Defog, Lav Hot Water	Limiter	20A	1	

FLAPS & CONTROL SURFACES				
Flap Asym Cont	CB	5A	1	Main CB Panel
Flap Pos Ind	CB	5A	1	
Stab. Trim Rate Cont	CB	3A	1	
Speed Stab.	CB	2A	1	
Yaw Damper	CB	5A	1	
Stab. Pos Ind	CB	2A	1	
Anti-Skid Brake-Flap	Limiter	20A	1	Dist, DC Pwr, Emerg Bus
Stab. Trim Motor	Limiter	5A	3	AC Pwr Dist Box

INSTRUMENTS				
LH Nav Instr Ampl	CB	3A	2	Main CB Panel
Angle-of-Attack Sensor	CB	2A	1	
Pitot Air Data Flt Instr	CB	2A	2	
Turn & Bank Ind	CB	2A	2	
Flt Recorder	CB	2A	1	
RH Remote Comp	CB	5A	1	
LH Remote Comp	CB	2A	1	
Autopilot	CB	7.5A	1	
26V AC Inst Bus Ct & Ind	CB	2A	1	
Instr Pwr	Limiter	3A	2	Elec Rack
Remote Comp	Limiter	1A	2	
Standby Instr Trans	Limiter	1A	1	Dist, DC Pwr, Emerg Bus
RH Remote Comp, Flt Dir	Limiter	5A	3	
Fire Det Fuel Flow				
Exh Ind	Limiter	10A	1	
Pitot Heat	Limiter	10A	1	
Ign & Panel Lts	Limiter	10A	1	
Instr & Pwr Fail Ind	Limiter	5A	3	
Air Temp — Tail A-I	Limiter	10A	1	
Eng A-I Excess Ht	Limiter	10A	1	
Main Instr Trans	Limiter	1A	1	AC Pwr Dist Box
RH Comp Air Data T&B	Limiter	20A	1	
RH Instr & Pwr Fail. Relay	Limiter	5A	3	

RADIO & COMMUNICATIONS				
Selcal 1 & 2 AC	CB	5A	2	Main CB Panel
Selcal 1 & 2 DC	CB	5A	2	
PA Ampl AC	CB	5A	1	
PA Ampl DC	CB	5A	1	
Tape Reproducer AC	CB	5A	1	
Tape Reproducer DC	CB	5A	1	
Audio Sel — Pilot & Radio Rack DC	CB	5A	1	
Audio Sel — Copilot & Flt Eng DC	CB	5A	1	
Nav Instr Bus Trans				
1 & 2 AC	CB	5A	2	
VHF Nav 1 & 2 AC	CB	5A	2	
VHF Nav 1 & 2 DC	CB	5A	2	
ATC Transp 1 & 2 AC	CB	5A	2	
ATC Transp 1 & 2 DC	CB	5A	2	
VHF Comm 1 & 2				
XMTR AC	CB	5A	2	
VHF Comm 1 & 2				
XMTR DC	CB	5A	2	
VHF Comm 1 & 2				
RCVR AC	CB	5A	2	
VHF Comm 1 & 2				
RCVR DC	CB	5A	2	
DMET 1 & 2 AC	CB	5A	2	
DMET 1 & 2 DC	CB	10A	2	
Marker Beacon AC	CB	10A	1	
Marker Beacon DC	CB	5A	1	
Radio Comp 1 & 2 AC	CB	5A	2	
Radio Comp 1 & 2 DC	CB	5A	2	
Radar AC	CB	10A	1	
Radar DC	CB	5A	1	
HF Comm 1 & 2	CB	5A	2	

EQUIPMENT	PROTECTOR	SIZE	QTY	LOCATION
RADIO & COMMUNICATIONS — CON'T.				
Ess Radio Bus AC	Limiter	10A	1	Dist DC Pwr, Emerg Bus
Ess Radio Bus DC	Limiter	20A	1	
Radio Emerg Bus	Limiter	20A	1	
Norm DC Radio Bus 1&2	Limiter	30A	2	
Doppler Radar Inst AC	CB	5A	1	Avionics CB Panel
Doppler Radar AC	CB	5A	1	
Doppler Radar DC	CB	5A	1	
Weather Radar AC	CB	10A	1	
Weather Radar DC	CB	5A	1	
Marker Beacon AC	CB	5A	1	
Marker Beacon DC	CB	5A	1	
Glideslope 1 & 2 AC	CB	5A	2	
Glideslope 1 & 2 DC	CB	5A	2	
Nav Inst 1 & 2 AC	CB	5A	2	
ATC Beacon 1 & 2 AC	CB	5A	2	
ATC Beacon 1 & 2 DC	CB	5A	2	
DMET 1 & 2 AC	CB	5A	2	
DMET 1 & 2 DC	CB	10A	2	
Selcal 1 & 2 AC	CB	5A	2	
Selcal 1 & 2 DC	CB	5A	2	
VGH Recorder DC	CB	5A	1	
LAS Recorder AC	CB	5A	1	
PA Ampl AC	CB	5A	1	
PA Ampl DC	CB	5A	1	
Speaker Ampl DC	CB	5A	1	
Audio Sel, LH Intph DC	CB	5A	1	
Audio Sel, RH, 2nd Ofcr DC	CB	5A	1	
Audio Sel, Flt Eng, Radio Rack DC	CB	5A	1	
Tape Reproducer AC	CB	5A	1	
Tape Reproducer DC	CB	5A	1	
Flt Recorder AC	CB	5A	1	
Flt Recorder DC	CB	5A	1	
VHF Nav 1 & 2 AC	CB	5A	2	
VHF Nav 1 & 2 DC	CB	5A	2	
VHF Comm 1 & 2				
Trans AC	CB	5A	2	
VHF Comm 1 & 2				
Trans DC	CB	5A	2	
VHF Comm 1 & 2				
Rcvr AC	CB	5A	2	
VHF Comm 1 & 2				
Rcvr DC	CB	5A	2	
Radio Compass 1 & 2 AC	CB	5A	2	
Radio Compass 1 & 2 DC	CB	5A	2	
Norm AC Radio Bus 1&2	Limiter	20A	6	AC Pwr Dist Box

EMERGENCY EQUIPMENT				
Flare Release	CB	10A	1	Main CB Panel
Spoilers — Emerg Pitch	CB	5A	2	
Stab. Trim Cont, Emerg	CB	5A	1	
Eng Emerg Hyd S/O Valve	CB	5A	4	
Fire Ext — Main & Reserve	CB	5A	4	
Eng Fire Det Sys	CB	2A	4	
Eng Fire Cont	CB	3A	1	
Eng Ovht Cont	CB	3A	1	
Fire Ext Sys	Limiter	20A	1	Dist, DC Pwr, Emerg Bus
Emerg Bus Ind Lt Rel	Limiter	5A	1	
Eng Hyd Oil Emerg Press.	Limiter	15A	1	
Emerg Lt	Limiter	5A	1	Battery Junc Box
LG Ovhd Horn	Limiter	5A	1	
Hot Water Htr	CB	7.5A	3	Main CB Panel

BUFFETS & LAVATORIES				
Buffets 1, 2, 3, 4	Limiter	10A	3	AC Pwr Dist Box
Pass Wtr Sys Press. Pump	Limiter	5A	3	
Pass Wtr, Air Cond, Eng Ice Det, Hyd Fluid Qty	Limiter	20A	20	
Lav Hot Water	Limiter	15A	1	
Lav Hot Wtr, Pilot Window Defog	Limiter	20A	1	

LIGHTS — ILLUMINATION				
Ent Ramp Recpt	CB	15A	2	Main CB Panel
Cabin Lts — Window	CB	7.5A	2	
Cabin Lts — Ovhd	CB	7.5A	2	
Cabin Lts Cont — Ovhd	CB	5A	1	
28V AC Ltg Trans, Cont	CB	5A	1	
Stew. Panel Fwd	CB	5A	1	
Stew. Panel Aft	CB	5A	1	
Flt Eng'r Panel	CB	3A	1	

EQUIPMENT PROTECTOR SIZE QTY LOCATION

LIGHTS — ILLUMINATION — CON'T.

Ped & Ovhd Panel	CB	2A	1	Main CB Panel
Inst Panel White	CB	2A	1	
Inst Panel Red	CB	2A	2	
Console Panel	CB	2A	2	
Magnetic Compass	CB	2A	1	
Flt Eng'r Flood	CB	2A	1	
Flt Eng'r Utility	CB	2A	1	
Flt Eng'r Compass	CB	2A	1	
Emerg & Cockpit Dome	CB	5A	1	
Inst Panel Hi-Intense Flood	CB	2A	1	
Pedestal Flood	CB	5A	1	
Coat Closet	CB	5A	2	
Outbd Landing	CB	10A	2	
Inbd Landing Cont	CB	5A	1	
Inbd Landing	CB	7.5A	2	
Anti-Collision	CB	5A	2	
Console Flood	CB	5A	2	
Elec Compt	CB	5A	1	
Air Cond & Hyd Compt	CB	5A	1	
Lavatory	CB	5A	1	
Map Reading	CB	10A	1	
Aisle	CB	3A	1	
Pilot Override Pass.	CB	2A	1	
Position	CB	7.5A	1	
Wheel Well & Pos Cont	CB	5A	1	
Pilot Heater	CB	2A	1	
Aft Cargo, Tail Compt	CB	7.5A	1	
Fwd Cargo Compt	CB	5A	1	

Aft Stew. Cont Panel	CB	5A	1	Aft Stew. Cont Panel
Buffet	CB	5A	1	
Entrance	CB	5A	1	
Lavatory	CB	5A	1	
Aisle	CB	15A	2	
Center Reading	CB	15A	1	
Window Reading	CB	15A	2	

Fwd Stew. Cont Panel	CB	5A	1	Fwd Stew. Cont Panel
Lounge	CB	5A	1	
Buffet	CB	5A	1	
Entrance	CB	5A	1	
Lavatory	CB	5A	1	

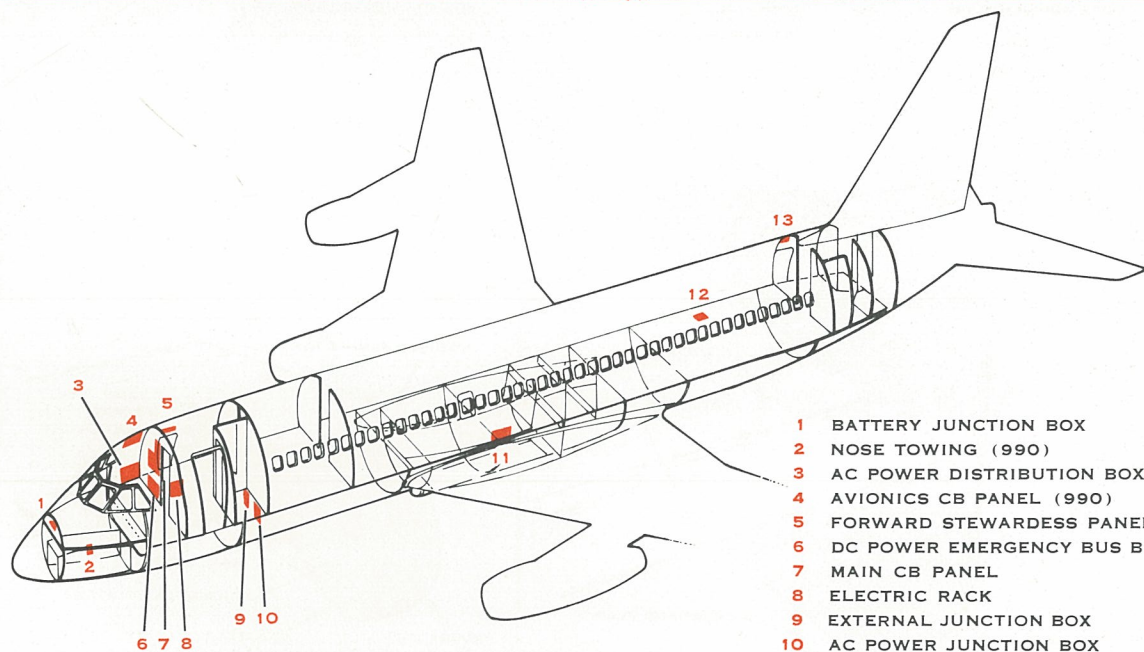
Pass. Reading	Limiter	20A	1	AC Pwr Dist Box
Gen Vac Recpt	Limiter	30A	1	
Ldg & Anti-Collision	Limiter	15A	1	
Landing	Limiter	20A	1	
Lav, Closet, RH Defog	Limiter	20A	1	

EQUIPMENT PROTECTOR SIZE QTY LOCATION

INDICATOR LIGHTS & WARNING DEVICES

LG Warn. Horn	CB	3A	1	Main CB Panel
LG Grd Safety Sw	CB	3A	2	
LG Pos & Warn.	CB	2A	1	
LG Handle Sol	CB	5A	1	
Anti-Skid Cond — NLG	CB	5A	1	
Anti-Skid Cond — MLG	CB	7.5A	2	
Cabin Alt Warn. Lt	CB	2A	1	
Pass. Call Sys Fwd	CB	10A	1	
Pass. Call Sys Aft	CB	5A	1	
Master Warn.	CB	3A	1	
Master & Warn. Lts Cont	CB	10A	1	
Door Open Warn. Lts	CB	2A	1	
Pass. Warn. Signs	CB	5A	1	
Lav Occupy Warn. Lts	CB	5A	1	
Gen AC Sys Ind Lts 2&3	CB	2A	2	
Gen AC Sys Ind Lts 1&4	CB	2A	1	
Pass. Water Cont & Warn.	CB	2A	1	
Struct Temp. Ind	CB	5A	1	
Wing Ice Lts	CB	7.5A	1	
AC Instr Pwr Fail Lts	CB	2A	1	
Wing Excess Ht Warn. Lts & Bleed Air Valves	CB	3A	2	
Fus Excess Ht Warn. Lt	CB	3A	1	
Struct Ovht Warn.	CB	2A	1	
Wing Skin Temp Ovht	CB	3A	2	
Wing Ovht Det	CB	5A	2	
Ovht Det — Fus	CB	5A	1	
Bleed Valve Ind Lts	CB	2A	1	
Freon Drive Warn. Lts	CB	5A	2	
Eng Duct Lip Valve & Ind Lts	CB	3A	4	
Eng Hyd Press. Low Warn.	CB	2A	4	
Hyd Temp & Ret Press. Warn. 1&2	CB	2A	2	
Oil Press. Low Warn. Eng 1&2	CB	2A	1	
Oil Press. Low Warn. Eng 3&4	CB	2A	1	
Fire & Ovht Warn.	CB	2A	1	
Exh Gas Temp Ind.	CB	2A	4	
Press. Ratio Ind	CB	5A	4	
Thrust Rev Warn.	CB	2A	4	
CSD Warn.	CB	3A	4	
VNE-MNE Warn.	CB	3A	1	

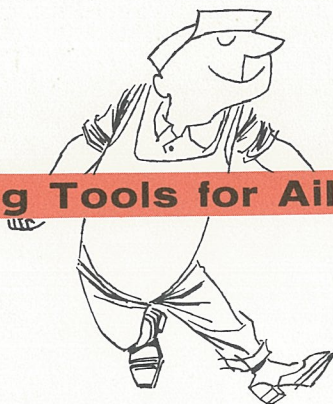
Master Warn. Box	Limiter	20A	1	Dist DC Pwr & Emerg Bus
LG — Flap Lts	Limiter	20A	1	
Bus Ind Lt Rel	Limiter	5A	1	



ELECTRICAL PROTECTOR BOX AND PANEL LOCATIONS

- 1 BATTERY JUNCTION BOX
- 2 NOSE TOWING (990)
- 3 AC POWER DISTRIBUTION BOX
- 4 AVIONICS CB PANEL (990)
- 5 FORWARD STEWARDESS PANEL
- 6 DC POWER EMERGENCY BUS BOX
- 7 MAIN CB PANEL
- 8 ELECTRIC RACK
- 9 EXTERNAL JUNCTION BOX
- 10 AC POWER JUNCTION BOX
- 11 TEMP CONTROL RELAY & CB BOX
- 12 CARGO LOADER JUNCTION BOX (990)
- 13 AFT STEWARDESS PANEL

Rigging Tools for Aileron Tabs



Four tools are used on the Convair 880 production line to check and rig the degree of deflection of the aileron trim and flight tabs. Two of the tools are locating fixtures, which are used to locate the control surfaces in the streamlined positions . . . P/N 22-19006-901 for the left-hand side and 22-19006-902 for the right-hand side. The other two tools are, essentially, protractors which are used to read the degrees of tab deflection. The protractor tools are P/N 22-17000-901 for the left-hand side, and P/N 22-17000-902 for the right-hand side.

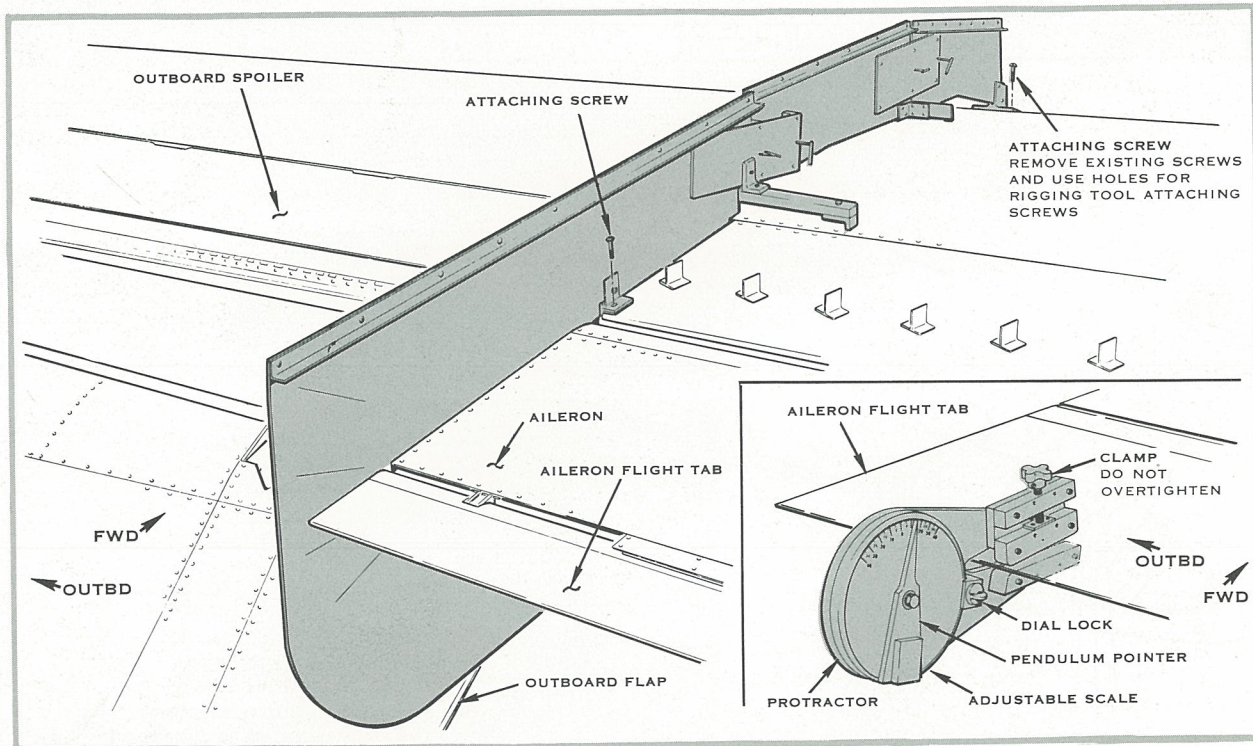
The right-hand and left-hand locating fixtures consist of a rigid tool, contoured to fit the upper surface of the wing, and a surface plate on which the streamlined position of the aileron is marked. The right-hand and left-hand protractor tools each consist of an adjustable clamping device, to which is attached an adjustable dial (graduated in degrees) and a free-swinging pointer mounted in the center of the dial.

To rig the tabs, the fixture is attached to the upper

surface of the wing at the front and rear spars, at a point where the surface plate can be inserted between the inboard edge of the outboard flap and the outboard edge of the aileron. Before checking the degree of deflection, it is necessary to adjust the aileron to the streamlined position, according to the marks on the surface plate.

To check the aileron flight tab deflection, the appropriate protractor tool (right- or left-hand) is clamped to the trailing edge of the aileron flight tab. The adjustable dial is then rotated to the zero index, in line with the pointer, and locked in this position by means of a locking screw. Degrees of deflection of the aileron flight tab can then be read at the point location on the dial.

Aileron trim tab deflection can be determined by attaching the appropriate protractor tool to the trailing edge of the aileron trim tab, and following the same procedure as that described for determining aileron flight tab deflection.



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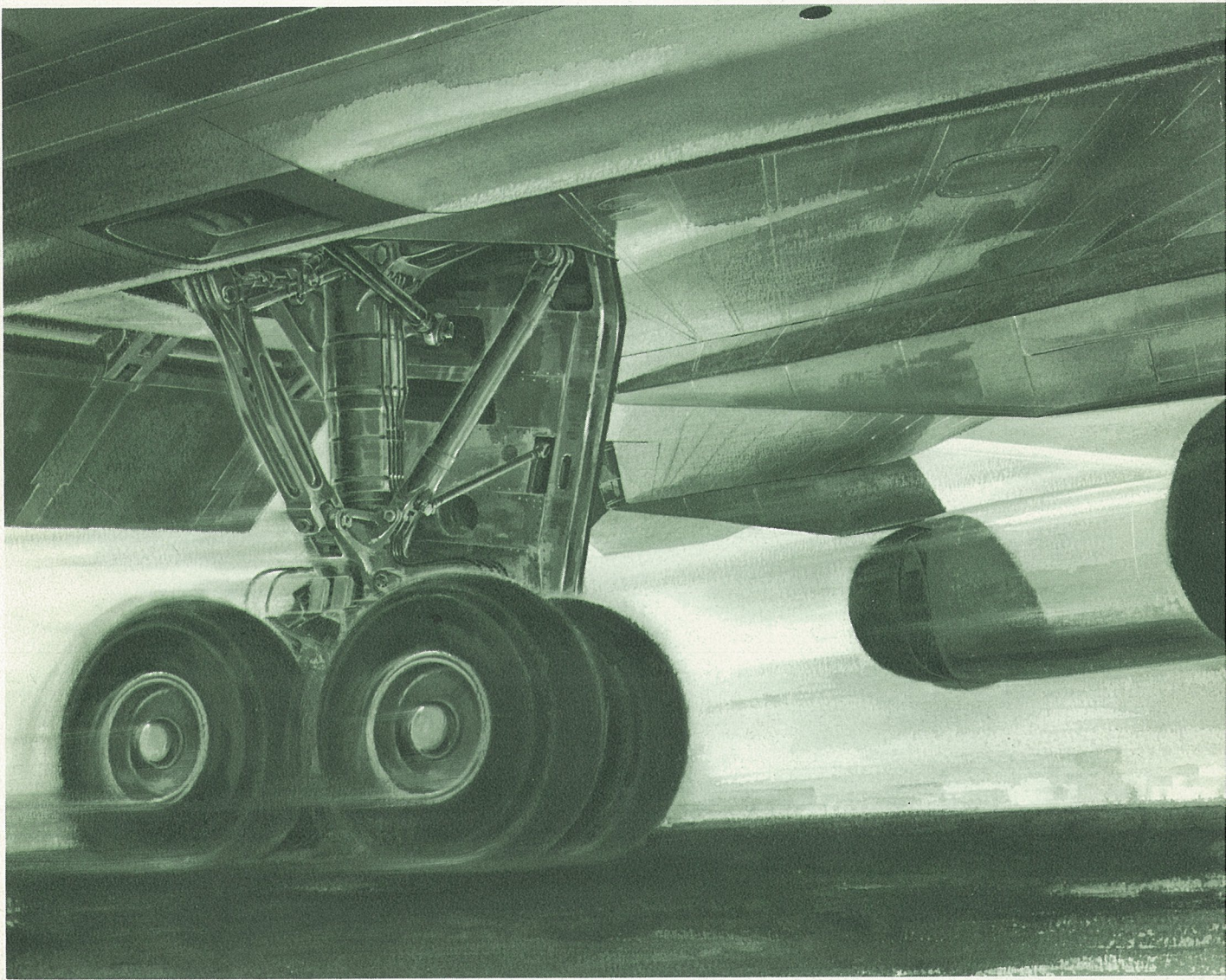
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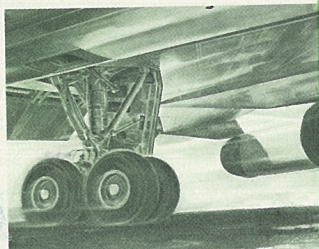
W. C. Campbell



In this Issue: Convair 990 Landing Gear

VOLUME XII NUMBER 12 APRIL 1961

Convair Traveler



In this Issue: Convair 990 Landing Gear

OUR COVER

Supporting over 100 tons at race car speeds is routine for the Convair 990 landing gear—an achievement of fine engineering. Jack Davis is the artist.

Convair Traveler

VOLUME XII NUMBER 12 APRIL 1961

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N. V. Davidson

A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

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Convair 990 Landing Gear

The evident family resemblance between Convair 880 and 990 jet airliners may obscure the fact that there are a number of structural differences not apparent at a glance. This is particularly exemplified in the landing gears of the two aircraft.

With the airplanes side by side, it can be seen that the "990" main gears are longer and heavier. A closer look will show that the gear is a new design. The aft drag brace has been eliminated. Downlocks on "990" main and nose gears are in jury braces between the folding elements and the struts, rather than in mechanisms at the "knees." Retraction mechanism of the nose gear is completely different.

Differences in materials and operation are less apparent. The "990" main gears carry approximately a third more weight than the "880" main gears. They are structurally designed for maximum taxi weight of 245,000 lb; for takeoff at 244,200 lb at speeds up to 195 kts; and for landing at 180,000 lb up to 180 knots. To obtain the requisite strength without undue weight penalty, more of the "990" parts are made of very-high-heat-treat steels. There are changes in geometry and in components such as brakes and tires.

This description, without pursuing the comparisons in detail, will take up the general structure, operation, and special characteristics of the "990" landing gears and associated systems.

OPERATION

Normal operation of the landing gear is by 3000-psi hydraulic pressure from the airplane's two hydraulic systems. The No. 1 system powers the nose landing gear, including door locks, brakes, steering, and the gear itself; the No. 2 system operates the main gears, doors, and brakes.

The landing gear control lever is on the right side of the center instrument panel. It has three positions: UP, NEUTRAL, and DOWN. In NEUTRAL, normal airborne position, hydraulic pressure is removed from the gear actuators at the selector and sequence valves. A solenoid-operated pin locks the control lever down when the airplane weight is on the struts, or when either main gear is not in proper position for retraction.

Gear and door position lights, beside the control lever, are off when the gear is fully retracted. Green lights illuminate to show gears down and locked; a red light comes on during transit, and remains on if gears

are not all down and locked, or not up and locked, or when the gears are in any position not compatible with control lever setting. A door red light shows when gears are retracted with any door not closed and locked, or when gears are down and a main landing gear door is not locked. (The nose gear doors are not locked while the gear is extended.)

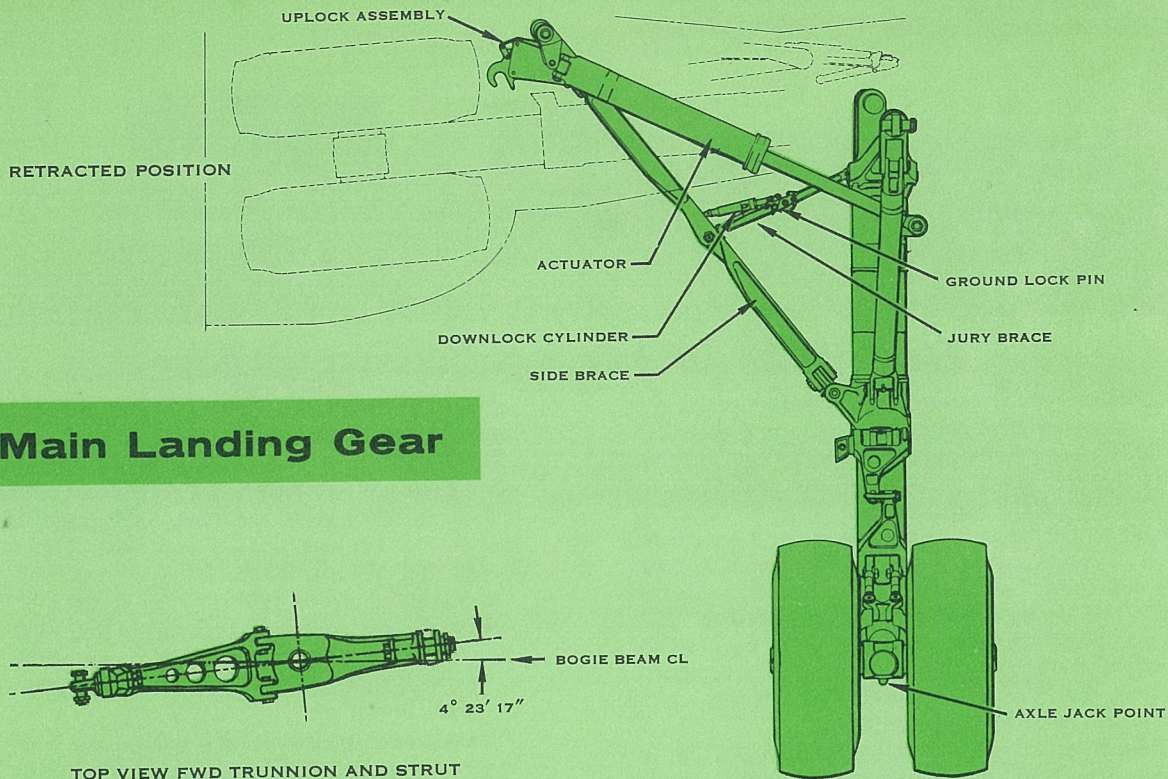
A warning horn sounds when the airplane is on the ground and the control lever is not locked in DOWN position; while airborne, it sounds if any power lever is retarded below 75% thrust and any gear is not down and locked.

Emergency gear extension is by free fall, controlled by a lever on the aft face of the center pedestal. The lever is mechanically connected by a chain-and-cable system with the nose gear door uplocks and gear uplocks, and with the main gear door and gear uplatch. First motion of the emergency lever vents the landing gear hydraulic lines to return, and opens MLG door uplocks mechanically. Main gear doors are opened by pneumatic pressure, supplied from the 200-cubic-inch accumulator in the landing gear hydraulic system.

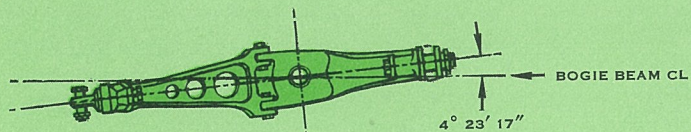
If No. 2 hydraulic system pressure fails, a check valve upstream of the accumulator isolates landing gear line pressure from the rest of the system. Even if hydraulic pressure is lost in landing gear lines, the accumulator will still have its precharge of 900 psi to open the main gear doors. Should the pneumatic pressure fail to operate properly, the weight of the gears will force the doors open and allow the gears to fall free. After emergency extension, the gear can be retracted in flight. Accumulator air will of course be lost and several cyclings may be necessary to bleed the lines. If any further emergency free-falls are necessary before charging the accumulator, the gear weight will open the doors and allow free-fall to the down-locked position.

In the "990," both nose and main gears are designed for extension at speeds up to 320 kts IAS for speed braking.

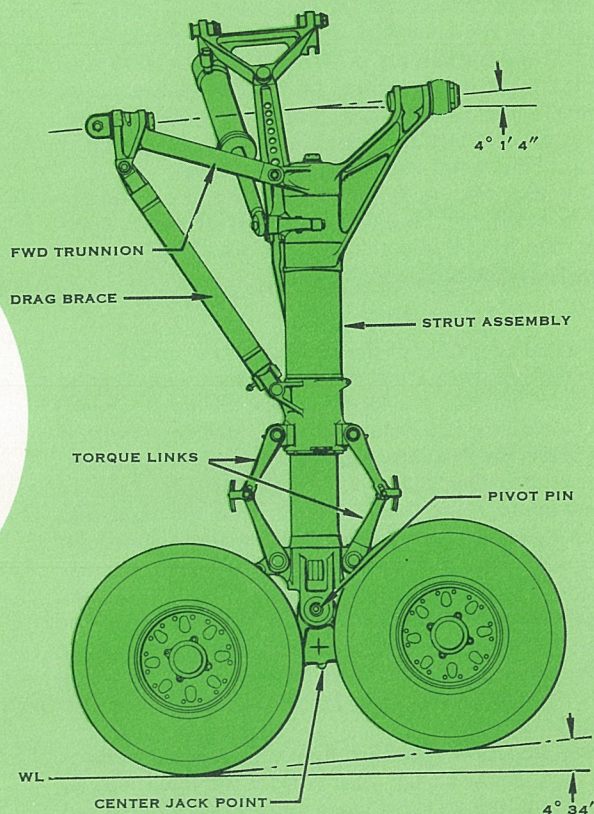
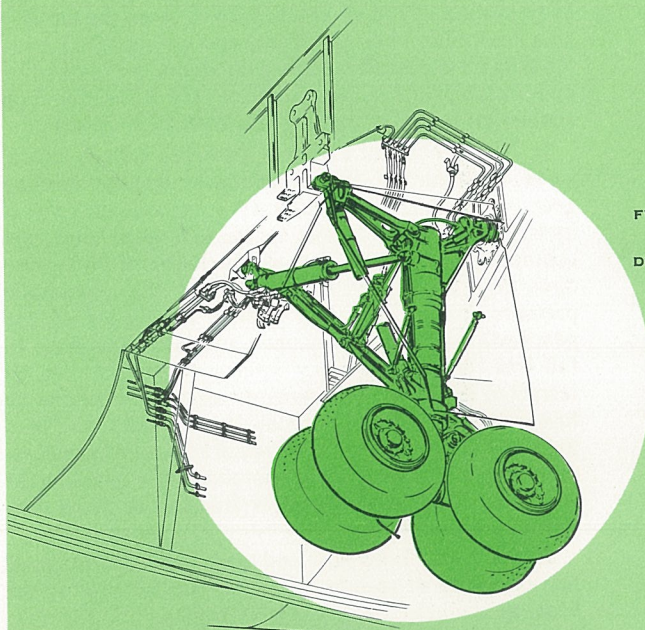
Brakes are operated by toe pressure on pedals linked by cables to brake metering valves. Emergency braking is applied to main gears only and is not controlled by the Hytrol system. Braking is pneumatic; pressure is supplied by an air flask mounted in the nose section, and controlled by a valve in the flight compartment.



Main Landing Gear



TOP VIEW FWD TRUNNION AND STRUT
SHOWING SKEW ANGLE



Parking brakes are set by depressing the brake pedals and pulling a parking brake handle, thereby locking the pedal control mechanism at the braked position. The brake accumulator will hold the brakes on for approximately an hour and a half, even though engines have been shut down and hydraulic system pressure is not available.

Nose wheel steering is controlled by a small wheel accessible to the pilot. Differential main wheel braking can be used for steering.

MAIN LANDING GEARS

Main landing gears have four-wheel trucks. Each truck is a tubular H-frame — a longitudinal "bogie" beam with axles at each end. Weight of the airplane rests near the center point of the bogie beam on a pivot pin, allowing the truck to rock longitudinally (around the lateral axis) through an arc of 33° 30'.

The yoke through which the pivot pin passes is the lower end of a conventional air-oil shock strut. Forward and aft torque links between strut piston and cylinder keep the truck aligned. With weight off the gear, an air-oil-spring truck positioner maintains the truck at 4° 34' aft end up with respect to airplane waterline (in contrast to the "880" truck position, which is 4° forward end up).

When the airplane weight rests on the gears in normal ground attitude, the positioner puts a preload on the forward truck tires. The bogie beam pivot point is therefore 1/4 inch aft of the longitudinal midpoint, to equalize tire loading.

The main gear strut is 10 inches longer than that of the "880" and is attached lower in the wing structure, so that the airplane stands approximately 18" higher at the main gears. Airplane waterline (and the cabin floor) normally slope 1° to 2° down toward the nose.

Basic frame pattern of the main gear is an inverted tripod, made up of the oleo strut cylinder, a forward drag strut, and an inboard side brace. The first two are load-bearing elements and are pin-mounted on the wing rear spar and the landing gear beam, which angles forward from the airplane centerline outboard to the inboard wing splice. Spar and beam are at the same relative position, with reference to the wing and fuselage spar boxes, as in the "880"; the landing gear center, however, is 11 inches aft of that of the "880." The oleo strut, therefore, instead of being 3 inches forward of the midpoint between spar and beam, as in the "880," is 8 inches aft of the midpoint.

The frame element attaching to the beam is an integral part of the strut cylinder. Forward, the spar attachment is to a trunnion from the top of the strut. The landing gear beam bears approximately twice as much of the airplane weight as does the wing spar. In consequence, the beam is considerably larger and stronger than in the "880."

The wheel well bears the same dimensional relation to wing spar and beam as in the "880." The gears, because they sit 11 inches farther aft, must therefore retract somewhat forward, rather than straight inboard. The pins on which the landing gear pivots during retraction are at an angle with the airplane centerline to allow the necessary "skew" in retracting.

The third leg of the basic tripod is the side brace, which braces the gear laterally on the ground, and folds as the gear retracts. Retraction is by a hydraulic cylinder, attached to the gear side brace structure, with its rod end attached to a fitting on the side of the oleo strut. A jury brace, between the knee of the side brace and the top of the strut, unfolds as the gear extends, and locks in the extended position to hold the side brace rigid on the ground. The downlock is a cam-and-roller mechanism in the jury brace knuckle, spring-locked in the down position and released by a hydraulic actuator. The main landing gear uplatch is a hook-and-roller type, normally locked and released by hydraulic actuator.

The main landing gear doors are hinged at the inboard side and open and close each time the gear is operated, whether raised or lowered. Mechanically-actuated sequence valves govern the gear and door hydraulic actuators. On the ground, the main gear doors can be opened and closed manually. A wing fairing, attached by links to the strut, and pivoted outboard of the trunnion, opens and closes with the gear.

High-strength steel (SAE 4340, heat-treated to 260,000-280,000 psi tensile strength) is used for the oleo strut cylinder, piston, bogie beam and pin, lower torque arms, and forward trunnion beam. Other steels used are AMS 6407, heat-treated to 220,000-240,000 psi; and SAE 4340, heat-treated to 200,000-220,000 psi. All sliding surfaces and moving joint pins are hard chrome-plated; other surfaces are chrome- or cadmium-plated. Aluminum alloys are 7178T and 7075T; drop forgings are 2014ST and 7079. All parts are interchangeable between right and left gears, except for the strut cylinders, which must be right- and left-hand parts, because of the skewed retraction.

NOSE LANDING GEAR

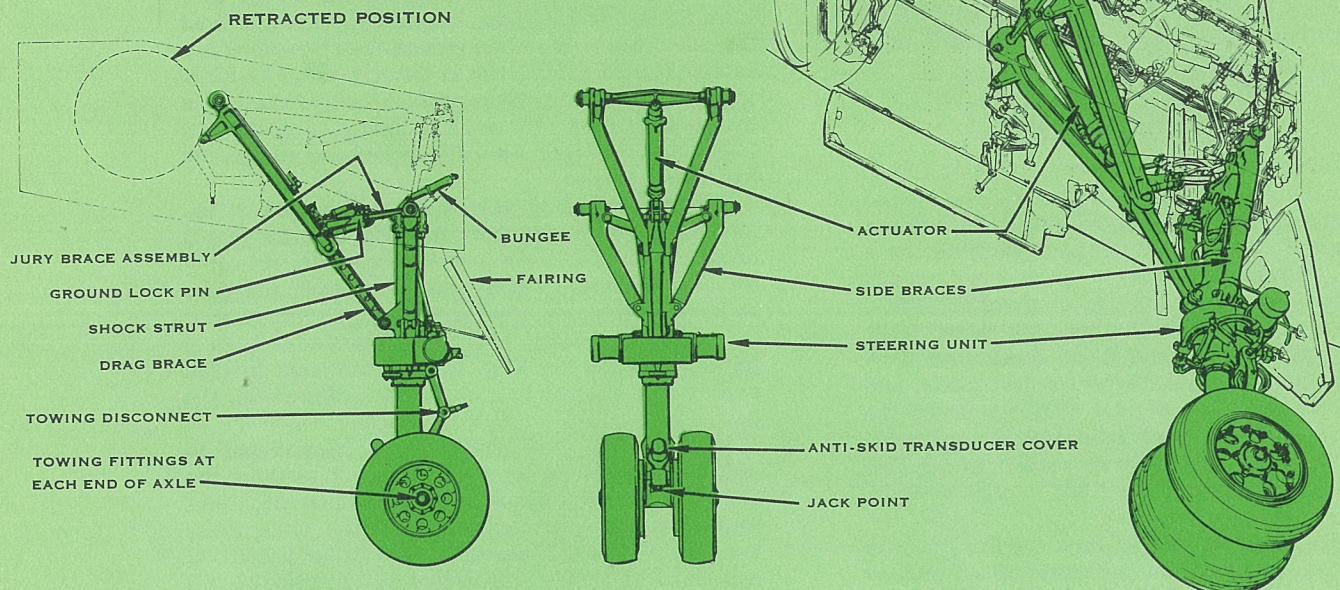
The nose gear strut assembly is about the same size and length as that of the "880," and is similar in many respects. Dual wheels are splined to a co-rotating axle; axle housings are integral with the shock strut piston. The nose gear load is carried on an inverted A-frame, made by side braces and trunnion bars attached to the strut cylinder and to the fuselage structure.

Retraction is forward. The lower drag brace, attached at the lower portion of the strut cylinder, joins an inverted A-frame consisting of the upper drag braces and a cross-beam. A jury brace attaches to the joint between upper and lower drag brace and to the top of the strut.

The hydraulic actuator is mounted at the center of the cross-beam between the prongs of the drag brace inverted A-frame. The rod end of the actuator attaches to a linkage assembly at the drag-brace-to-jury-brace joint; the actuator is approximately in line with the upper drag braces. The jury brace functions as both downlock and uplock.

Retraction and extension are as follows: When the gear is extended, the actuator is fully retracted, and the jury brace is locked in its in-line position by a cam-and-latch mechanism at the knuckle. The actuator

Nose Landing Gear



extends to retract the gear. First movement of the actuator rod end unlocks the jury brace; further movement "breaks" the jury brace, causing the drag brace to "break" also. As the jury brace folds, the drag brace also folds, pulling the gear up. By the time the jury brace is folded to its limit, the actuator force is being directed at an angle that continues to fold the drag brace, and the jury brace begins to straighten out. When the actuator is fully extended, the drag brace is completely folded, the gear is fully retracted, and the jury brace is again locked in line by the cam and latch, thereby locking the gear up.

Gear extension reverses the process: the jury brace unlocks, folds as the gear starts down, then straightens again to lock the gear open. Spring compression holds the jury brace locked; it is released by lever action of the linkages through lost motion of the gear. Uplock and downlock thus operate without hydraulic actuation.

There are two nose wheel well clamshell doors forward, and a fairing attached to and traveling with the gear. The clamshells are mechanically operated and are cycled closed by the last portion of gear extension. They can be opened manually on the ground. The clamshells, if left open on takeoff, will retract automatically when the gear is retracted.

Steering is by a rack-and-pinion drive, powered by dual hydraulic actuating cylinders. Steering range is 63° each side of center. Torque arms transmit the steering rotation to the wheel-and-axle assembly. Should hydraulic power fail, the wheels are free to caster. Removal of a quick-disconnect pin in the

torque arm joint permits towing within normal turning radius; 360° rotation is possible by disconnecting hydraulic and electric quick disconnects. The towbar attaches to cups in the axle ends.

High-strength steel (260,000-280,000 psi tensile strength) is used for the "990" strut piston, forward jury brace link, brace bolt, drag brace pin, torque arm collar, and the steering rack, pinion, lug pinion, piston bearing and eccentric bolt.

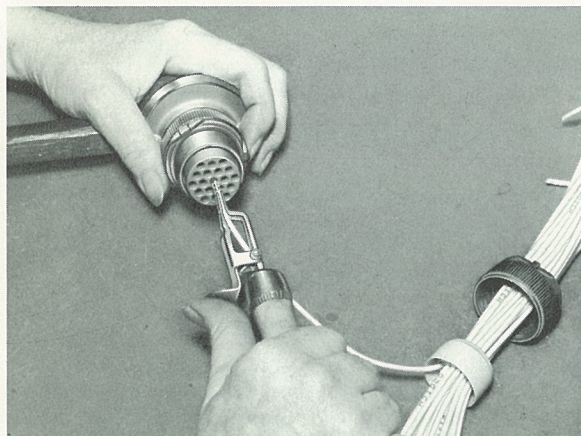
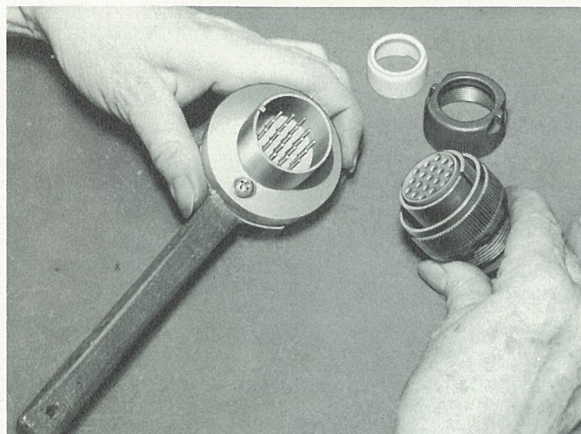
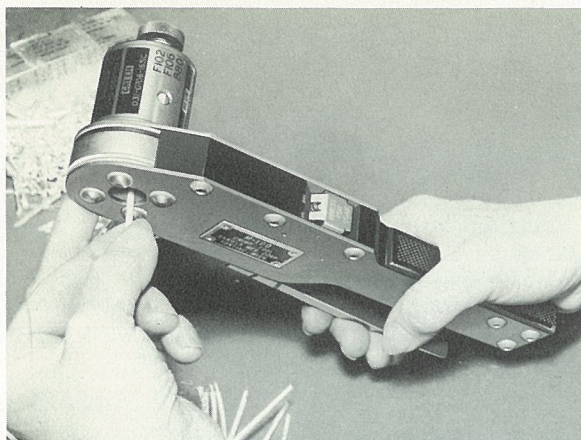
WHEELS, BRAKES, ANTI-SKID

Wheels and brakes for the Convair 990 are supplied by Bendix. All wheels are split-rim, designed for tubeless tires. Each wheel has three fusible plugs to relieve tire pressure in event of excessive heat buildup in the wheel.

Nose gear tires are 29 x 7.7, 16-ply rating, Type VII; main gear tires are 41 x 15.0-18, 22-ply or 24-ply (depending on customer requirements), Type VIII. The type VIII tires have wider tread for the tire depth and are the best available design for handling heavy loads at high speeds.

Brakes are free-floating, multiple-disc, ceramic-metallic type, hydraulically operated. Nose brakes are automatically deactivated whenever the nose wheel is turned more than $7^\circ \pm 1/2^\circ$ from center.

Braking is monitored by a Hytrol anti-skid system. Each main wheel brake and anti-skid mechanism operates independently. A transducer, mounted in the axle end, senses wheel velocity and deceleration, and causes the anti-skid control unit to release or apply pressure to the brakes as required.



EX Electrical Connectors

Assembly and Installation

EX type electrical connectors are designed for use in areas where high temperatures are encountered and expeditious repairs and replacements may be desired. The units can be quickly assembled and disassembled, and single contacts can be individually replaced without replacing the entire electrical connector.

The harness wires to the *EX* unit are fastened to the contacts by crimping rather than by soldering. This feature insures reliable contact in areas where elevated temperatures might exceed the melting point of the solder. Contacts are retained within the connector body by an insert material of heat-resistant silicon rubber. A compression nut (end bell) at the back of the connector body compresses the silicon rubber insert to form a moisture-proof seal. The rubber insert is not to be removed from the connector body.

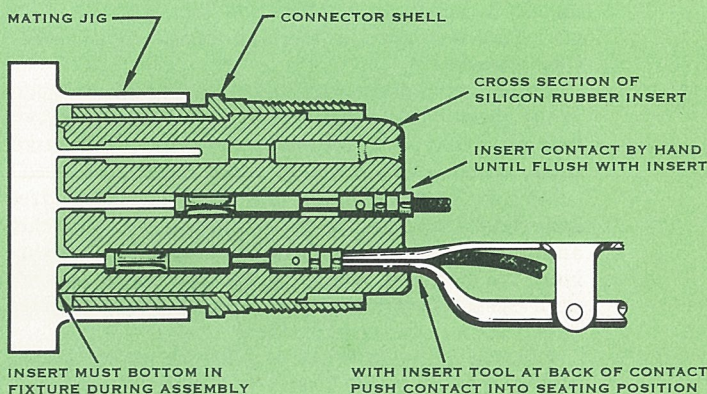
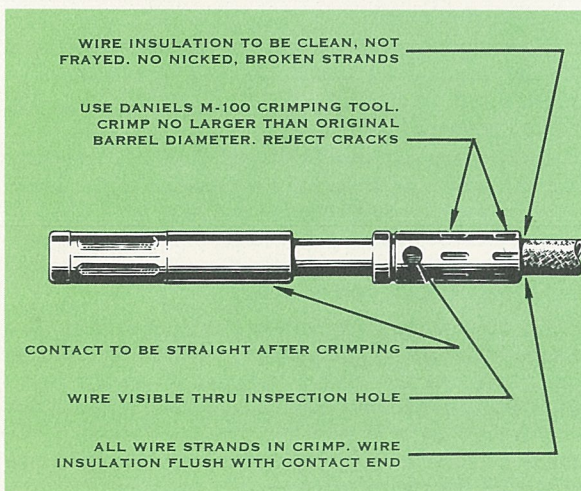
By employing the right tools for the job, assembling and servicing the *EX* electrical connectors can be accomplished with a minimum of time and effort. Daniels M-100 crimping tool is recommended for crimping the contacts; a Cannon insert tool is used for inserting the contact into the silicon rubber insert.

During assembly, it is important to keep the contacts free of grease and oil, because silicon rubber inserts become extremely "slippery" when in contact with lubricants, and lose their retaining qualities.

Before inserting wire into a contact, insulation should be stripped approximately $\frac{1}{4}$ inch from the end. The insulation should be cut clean, and wire strands should not be nicked or broken.

The contact is inserted into the appropriate die cavity of the crimping tool where it is held securely with its shoulder against the stop. Wire is then inserted into the contact with the insulation butted against the contact end, and the contact is crimped.

In photos from top to bottom: Contacts are fastened to wire ends by crimping tool. Connector is positioned on mating jig. Contact is pushed into insert with inserting tool.



To meet specified requirements, pull tests should be made to determine the tensile values of crimped contacts. During inspection, wire should not be bent at its connection to a contact.

Proper positioning of the contacts in the silicon rubber insulator may be determined by measuring from the face of the insulator to the tip of the contact. This dimension should be .200 for the red insulator, and .080 for the green insulator.

A mating connector, or locally manufactured jig, of the correct size is used as an aid in assembly. A Cannon insert tool (035649-0000) and a strap wrench are also used.

The connector is placed on the mating jig and pushed all the way to the bottom. The contacts are inserted in the insert openings (in planned sequence) until the socket contacts rest securely on the fixture pins. They are then pushed down by hand until they are flush with the back of the insert. The wire insulation at the back of the contact is gripped with the insert tool, and the contact is pushed into seating position. The inserting tool is then withdrawn.

The connector is sealed with a plastic compressor ring and with an end bell that is screwed on with a strap wrench. When properly positioned, the contact is firmly seated in the insert.

If the contact is clean and the end bell of the connector unit is tightened, the assembly should remain trouble-free indefinitely. For maximum retention of the contacts, all holes should be filled with contacts, and with plastic or wire plugs.

Contacts should always be inserted from the back side of the connector and should never be pulled through the insert from the inside. When disconnecting the plug, the connector body should be pulled — not the wiring harness.

By exercising reasonable care and observing the following rules, *EX* electrical connectors should give trouble-free service for the life of the wiring.

1. Wire should be stripped, leaving a clean insulation cut with no nicked or broken strands.
2. After crimping, all contacts should be checked for neat application and to insure tightness of the wire.
3. Contacts with flashings exceeding the original diameter of the contact should be rejected and the crimping tool checked.
4. Wire insulation should butt up against the end of the contact.
5. Contact barrel should not be split.
6. There should be no lubricant on the contacts or on any part of the connector assembly.

Before sealing, all connectors should be inspected for 1) proper seating of contacts, 2) damage to the insert material, 3) frayed wire insulation, and 4) lubricant on assembly.

After sealing, torque lacquer should be applied to the end bell and plastic compressor ring. If torque lacquer indicates that seal is broken, the connector assembly should be reinspected.

Null-Field Static Dischargers

Thirty-five null-field static dischargers are installed on the wing and horizontal and vertical stabilizers of Convair 880/990 jet airliners to reduce the noise, and increase the range of low frequency radio receivers. The range of low frequency receivers, such as the automatic direction finder, are increased as much as four times — from 10 to 12 miles up to 40 to 50 miles.

Low frequency radio receiver noise and the resultant restricted range is usually caused by precipitation static or engine exhaust gas charges. Precipitation static is primarily due to triboelectric charging (resulting from friction) that occurs when two dissimilar materials contact each other and then separate — as when hair is combed, or when an aircraft flies through precipitation.

When precipitation particles, dust, and other objects in the air collide with the airframe, the engine exhaust ions are freed by combustion heat, and the aircraft tends to acquire an electrically-charged (unbalanced) condition. Engine exhaust gas ions, as well as free ions loosed by impact, are caught in the airstream and swept away. When escaping ions fail to recombine, an electrical charge builds up on the aircraft until the surrounding air is ionized (forming corona) to provide a path to replace them.

Corona, often observed by pilots as purple arcing, and referred to as St. Elmo's fire, is the discharge of electrical current into the surrounding air when the electrical field at the object surface exceeds a critical

value. Corona discharges occur as very rapid short pulses of current, and produce a noise spectrum containing considerable energy at low radio frequencies. Unless controlled, they blanket desired signals.

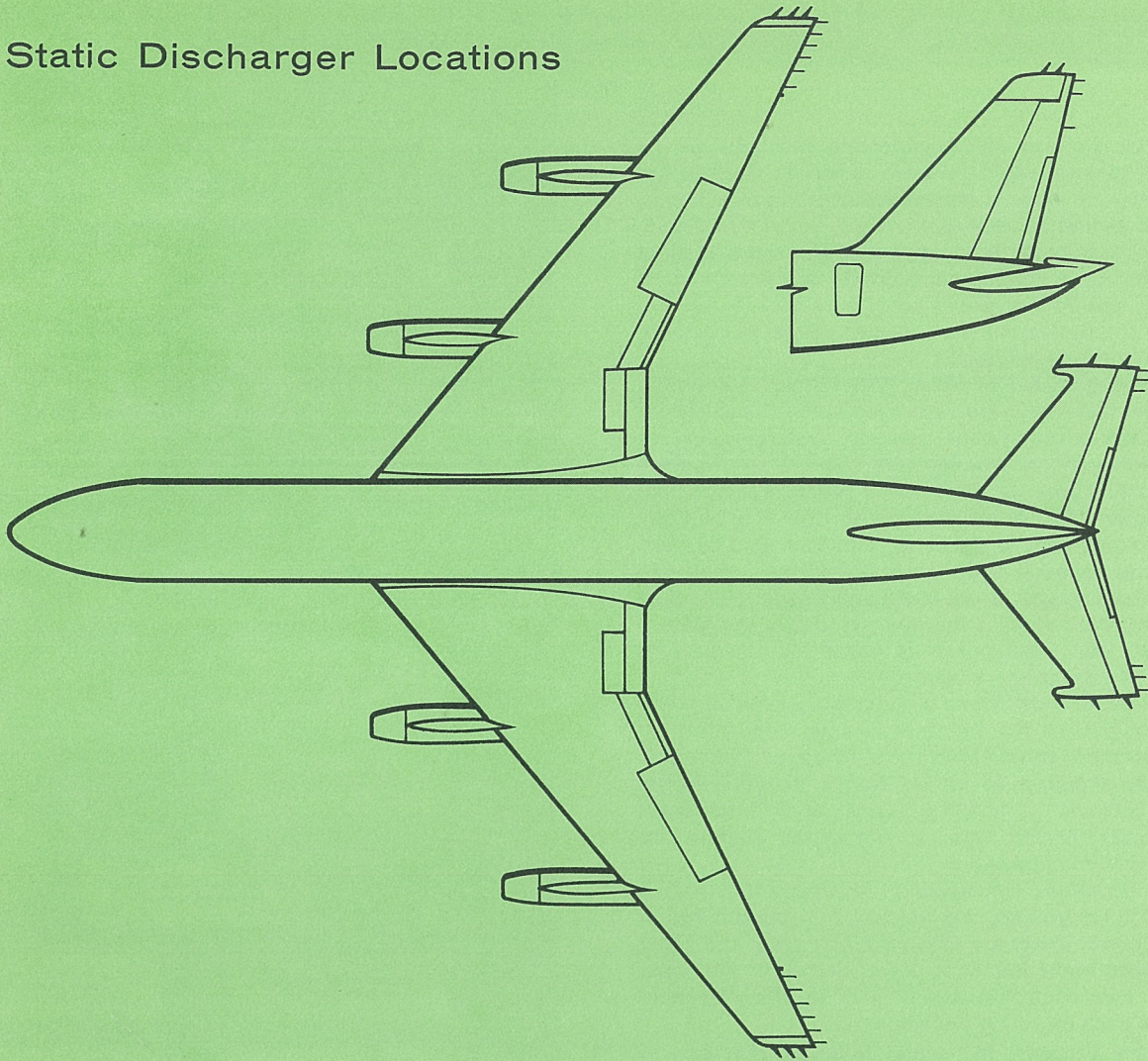
Electrical charges acquired by aircraft, and the resultant corona discharges, cannot be prevented. It is possible, however, to modify the fields in the discharge region to provide points that will correspond to zones of zero radio frequency, coupling with respect to the susceptible antenna system. This is the function of the null-field discharger.

Two types are in use on Convair 880/990's — a slender pencil-sized model for trailing edges; and a shorter size, resembling a vortex generator, for wing and empennage tips.

Sharp tungsten needles extend from an area near the discharger tips and at right angles to the body. The tip radii of these needles are kept very small so that the corona threshold voltage will be correspondingly low. This feature assures that the discharge will occur only at these control points.

The dischargers are installed in special mounting flanges attached to the airplane surface. The flanges are riveted to the skin or bonded by means of an electrically-conductive plastic adhesive. The recommended adhesive is available through Granger Associates . . . No. 610-1016 for one-ounce kits, and No. 610-1017 for half-pound lots.

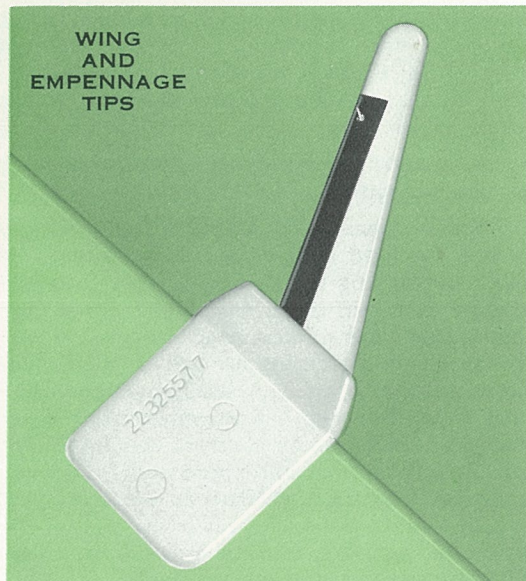
Static Discharger Locations



WING
AND
EMPENNAGE
TRAILING EDGES



WING
AND
EMPENNAGE
TIPS



Audible Warning System

In the Convair 880, a horn and two bells are installed to warn the flight crew if certain controls are not properly set or if immediate attention or action to some function is required.

The automatic warning horn has three distinct sounds: 1) a continuous note; 2) equal on-and-off sound; and 3) a repeated long on and short off note. These three different horn sounds advise the crew of the following conditions.

Continuous Sounding Horn. With the airplane on the ground, this sound indicates that landing gear lever is not in the locked (detent) position, or the landing gear lock solenoid (at landing gear handle) is unlocked. When airborne, the continuous sound indicates that any power lever is retarded below 75% rpm and any one landing gear is not down and locked. The horn will also sound if flaps are extended more than 43° when landing gear is not down and locked. (An interrupter switch enables the pilot to silence the horn if desired, but when power is advanced, the horn is automatically reset for warning.)

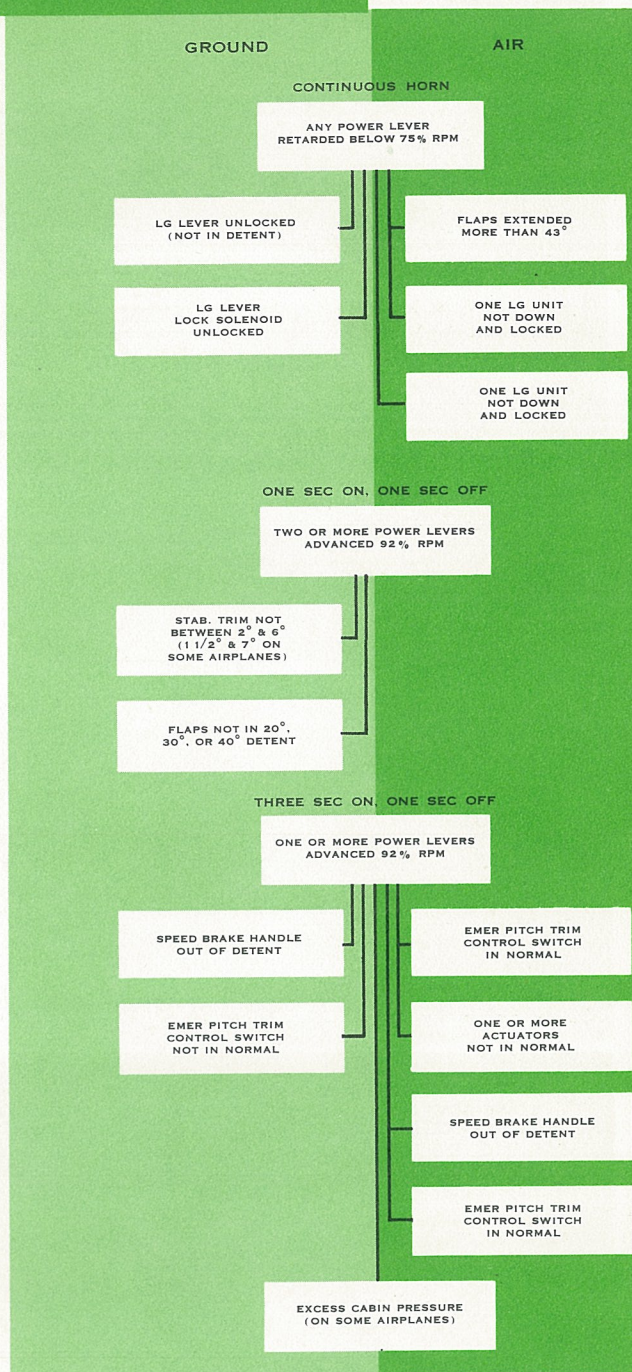
Equal-On-and-Off Sound (1 second on, 1 second off). On the ground, this intermittent sound indicates that two or more power levers are advanced 92% rpm, and the stabilizer is not positioned for takeoff trim (not between 2° and 6°; 1 1/2° and 7° on some airplanes), or the flaps are not in the 20-, 30-, or 40-degree detent position.

Long On, Short Off Sound (3 seconds on, 1 second off). On the ground, this warning will sound if two or more power levers are advanced 92% rpm, and either the speed brake handle is out of detent, or the emergency trim control switch is NOT in normal (either set for pitch up, or for pitch down).

When airborne, the sound indicates that two or more power levers are advanced 92% rpm with the emergency pitch control switch in normal, but either the speed brake handle is out of detent or one or more of the actuators is not in normal position. The horn will also sound any time that excess cabin pressure should develop.

Two different sounding bells supplement the horn warning systems.

Continuous Sounding Bell. One of the warning bells, located overhead in the flight compartment, sounds with a steady ring any time an overheat condition or possible fire exists in an engine pod. When the bell sounds, and either of these conditions exist, a red light will appear in the engine fire-pull handle to indicate the engine pod affected. A steady light and bell indicates a fire warning, and an intermittent light and steady bell indicates an overheat condition. By proceeding with the fire control procedure for this engine, it can be determined whether the overheat is caused by a leak in the hot section aft of the vertical firewall or by an actual fire, forward of the vertical firewall. Extinguishing action will be necessary.



Intermittent Bell. In flight, a bell, located forward and to the left of the pilot, will ring intermittently if airplane speed nears the VNE/MNE limitation of the airplane. This bell, commonly referred to as the "Veenie Meenie" bell, is a part of the Mach/Airspeed Never-Exceed Warning System.

On some Convair 880's, a gong gives an audible warning of terrain obstruction within a pre-selected range.

Rudder Rigging Tools Convair 880

The Convair 880 production line employs a rigging tool (in three parts), for checking the rigging and operation of rudder controls. This tool is designated RGTL 22-15000-901.

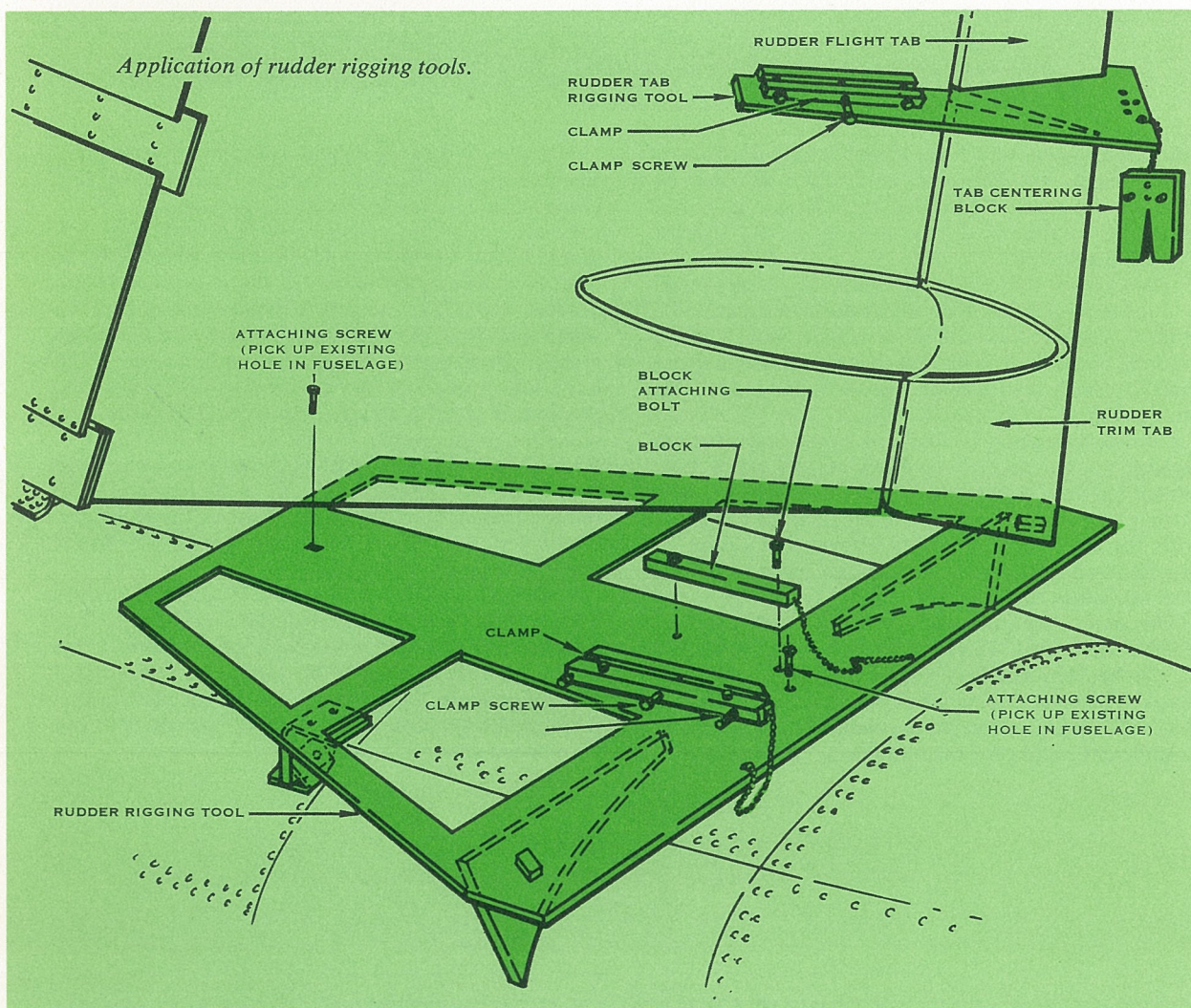
RGTL #1 is a flat aluminum plate, marked to show the streamline position and left and right full throw of the rudder. The tool can be used to lock the rudder in any one of these positions. When in position on top of the fuselage just under the rudder, it is held normal to the rudder by a base that is contoured to fit the fuselage at this point. Holes in the centerline of the tool correspond to screw locations at buttock line 0.00, station 1481.65 and 1511.65, on top of the fuselage. These holes are used for tool alignment.

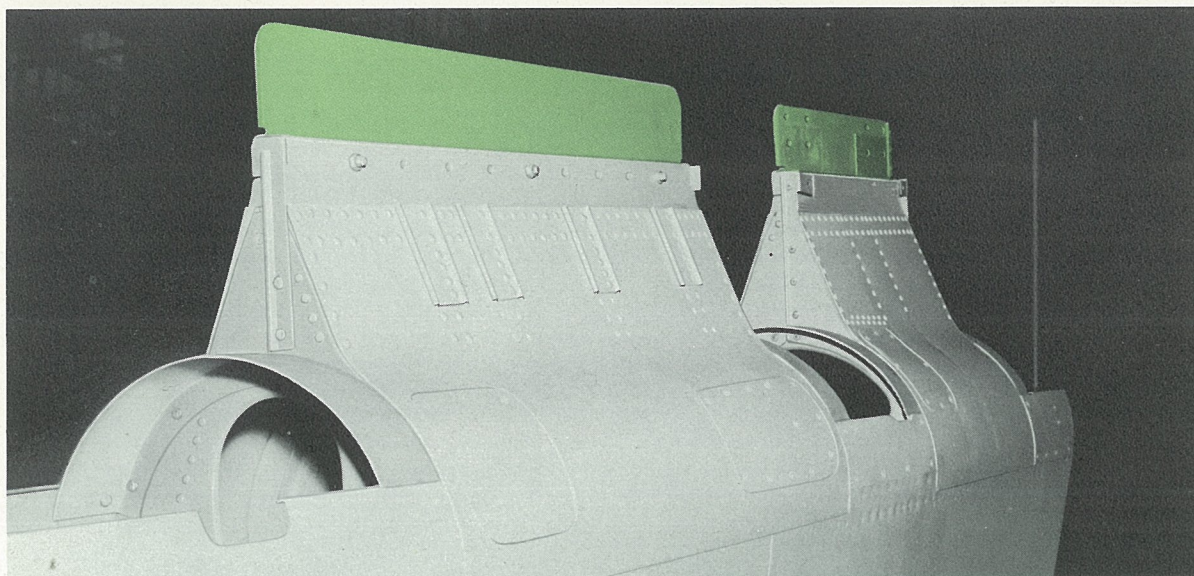
RGTL #2 is a similar plate (without base), graduated to show degrees of tab movement. The top side of the plate contains gradations for the rudder flight tab; the lower surface contains gradations for the trim tab. The plate is equipped with blocks on the

forward edge which clamp the plate to the rudder between the two tabs. In this way, both the rudder trim tab and rudder flight tab may be checked simultaneously.

RGTL #3 is a small block of 3/4-inch aluminum, resembling a truncated triangle $3.500 +.000, -.010$ inches across the rounded corners of the base. It is notched and fitted with a screw hook and a hole to permit it to act as a lock on the flight tab. The two forward bolts are removed from the rudder hinge line bellcrank support assembly when the tool is used. The hook is placed around the aft side of the stop and tightened by means of a nut on the screw hook. This clamps the tool securely to the rudder flight tab stop so that the rounded corners of the tool bear firmly against, and hold, the hinge line bellcrank in neutral position.

Tool drawings may be obtained from Convair for local manufacture of the rudder rigging tools.





Uranium balance weights attached to rudder during assembly.

Heavier Metal Makes A Lighter Airplane

An industry-wide search for lighter metals of comparable strength has been systematically conducted by airplane designers. For some applications, however, metal of maximum density results in the lightest overall installation.

The Convair 990 utilizes uranium — a heavy metal — for the fabrication of counterbalance weights in the control surfaces because it is heavier for a given volume. Since there is limited space available, a dense material such as uranium proved ideal for this application.

Control balancing is achieved by adding uranium weights to the surface forward of the hinge line, permitting the counterweight center of gravity to move farther forward, while maintaining the same clearance with the fixed surface limits. Moving the center of gravity limits forward increases the lever arm, and thus minimizes the weight required.

On early Convair-Liner aircraft, lead counterweights were used. The Convair 880 design made use of the heavier-than-lead sintered tungsten, but this material presented some fabrication problems. During the "990" design, depleted uranium became available in sufficient supply for manufacturing applications.

Uranium is approximately 11% more dense than sintered tungsten, and has a density 165% that of lead. Being ductile, it can be readily fabricated.

Natural uranium consists essentially of three isotopes, U234, U235, and U238. Only one, U235, is useful for fission. By means of the gaseous diffusion process, the U235 isotope is concentrated and the waste product, or depleted uranium, has a much greater percentage of U238. Inasmuch as the U238 has a lower specific radioactivity than U235, depleted uranium is safer to handle than natural material.

Although the weights are stenciled, "CAUTION — RADIOACTIVE MATERIAL," they may be handled with complete safety. They are cadmium-plated to reduce oxidation, dusting, and spread of uranium contamination. The plating effectively acts as a shield for the alpha and some beta radiation.

Uranium, comparable in cost to tungsten, is slightly heavier, but somewhat less material is needed.

Whenever weight can be saved, the economic value of the aircraft is edged a bit higher. It is estimated that by going to the heavier uranium for control surface counterweights, the weight of the aircraft will be reduced about 65 pounds.

Convair Traveler

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